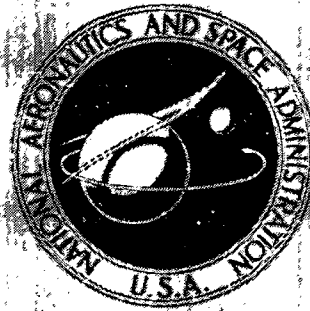


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**COMPUTER PROGRAM FOR CALCULATING
SUPERSONIC FLOW ON THE WINDWARD
SIDE OF CONICAL DELTA WINGS
BY THE METHOD OF LINES**

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CONTENTS

	Page
SUMMARY	1
INTRODUCTION	1
METHOD OF LINES	2
CONICAL-WING GEOMETRY	4
APPROXIMATE SHOCK SHAPE FOR CONICAL WINGS	5
PROGRAM OPERATION	5
Input Description	5
Output Description	9
Auxiliary Definitions	11
Secondary Parameters	13
Summary Print Block	13
Zeta Print Blocks	14
Accuracy Control Parameters	16
Limitations	17
Special System Features	18
APPENDIX A – REMARKS ON COMPUTATIONS FOR CIRCULAR AND ELLIPTIC CONES	19
APPENDIX B – PROGRAM LISTING, LIST OF SUBROUTINES, AND FLOW CHART	20
APPENDIX C – SAMPLE COMPUTATION	46
REFERENCES	56

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SUMMARY

This paper is a user's manual for a program which calculates the supersonic flow on the windward side of conical delta wings with shock attached at the sharp leading edge by the method of lines. The program also has a limited capability for computing the flow about circular and elliptic cones at incidence. It provides information including the shock shape, flow field, isentropic surface-flow properties, and force coefficients. A description of the program operation, a sample computation, and a FORTRAN IV program listing are included.

INTRODUCTION

In reference 1 the so-called method of lines was developed for obtaining numerical solutions of general supersonic conical flow problems, that is, those gas-dynamic problems in which the fluid properties do not vary along rays emanating from a common point in the flow. The method was applied to circular and elliptic cones and to the windward side of conical delta wings with shock attached at the sharp leading edges.

This paper describes a computer program which uses the method of reference 1 and which is primarily designed for the delta-wing problems just mentioned. The program provides information including the shock shape, flow field, isentropic surface-flow properties, and force coefficients. The program also has a limited capability for the calculation of flow about the circular and elliptic cones, but a more efficient version is available for those problems and is described in reference 2. Some remarks concerning the operation of this program for the circular and elliptic cones are relegated to appendix A.

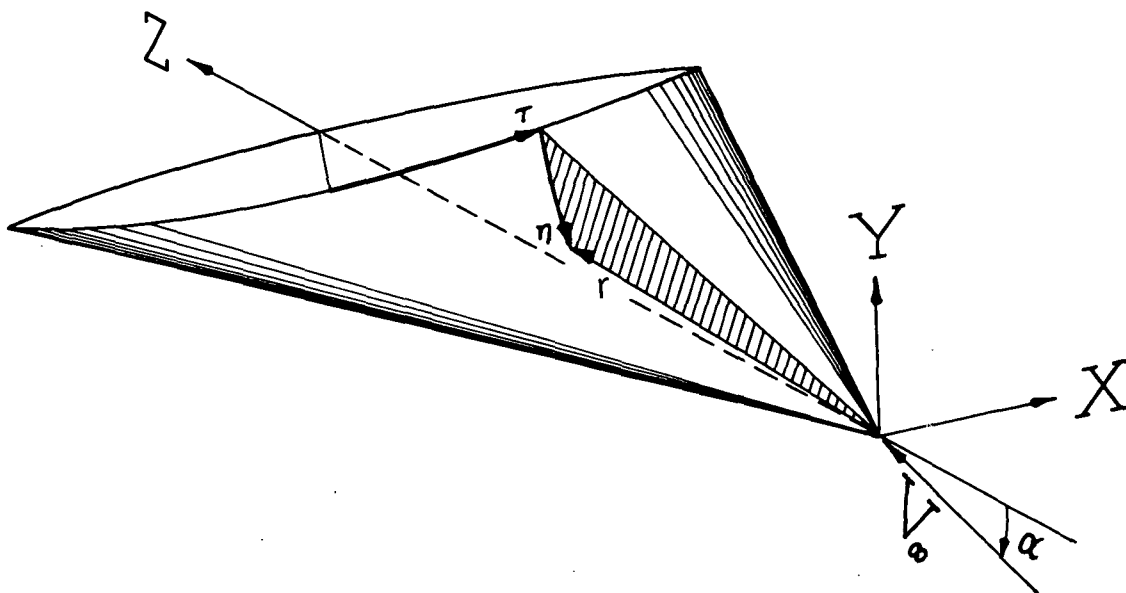
The present program has a built-in capability for three different conical-wing cross sections: flat plate, circular arc, and modified wedge. The modified wedge is a wedge cross section with the center ridgeline rounded by a circular arc of user-specified radius; a sharp ridgeline is approximated by a very small radius. Other cross sections can be included in the program without much difficulty.

The mathematical method and coordinates are described very briefly, and details of the operation of the program are given herein. A listing of the computer program is given in appendix B together with a list of the subroutines and a flow chart. Appendix C presents a sample computation.

METHOD OF LINES

The method of lines was developed in complete detail in reference 1; hence, only a brief description is presented herein. The flow equations are initially written in a body-oriented, orthogonal, conical coordinate system (r, η, τ) , as shown from below and behind the wing in sketch (a), where r is the distance along a conical ray, η is the angle measured from the body surface to the ray in a plane where τ is constant, and τ is a measure of the arc length along the intersection of the body surface with a sphere of radius r centered at the body apex. Specifically, τ is determined by numerical integration on the unit sphere. The free-stream velocity vector V_∞ lies in the YZ-plane of symmetry, and the origin of the arc length τ is taken in the windward plane of symmetry. All computations are made in the right half-plane. The integration of the system of equations is facilitated by a coordinate transformation which maps the region bounded by the shock and the body into a rectangular domain. The transformed variables are

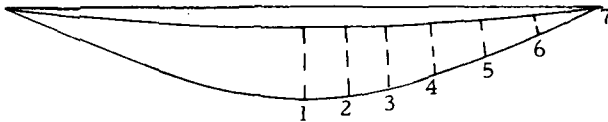
$$\xi = \frac{\eta}{\eta_s} \quad \text{and} \quad \xi = \tau$$



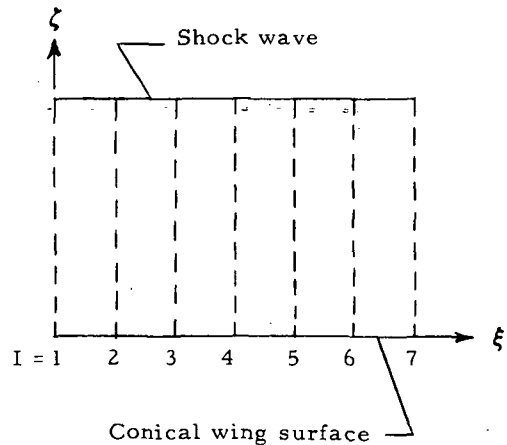
Sketch (a)

where $\eta = \eta_s(\tau)$ is the shock surface. Thus, $\xi = 0$ on the body, and $\xi = 1$ on the shock.

The ξ, ζ -plane is divided by $N + 1$ lines parallel to the ζ -axis; the line $I = 1$ is taken in the windward plane of symmetry, and the line $N + 1$ is at the wing leading edge, where the shock is assumed to be attached. The layout of the computational lines for $N = 6$ is shown in sketch (b). At each line the system of differential equations is reduced to a set of ordinary differential-difference equations by replacing the derivatives $\partial/\partial\xi$ by finite differences. The derivative of the Lagrange interpolation polynomial is used in this program with an equal number of lines on either side of the line at which $\partial/\partial\xi$ is computed; therefore, central differencing is obtained when the line spacing is equal. The initial values for the system of equations are determined from the shock relations once the shock shape is specified, and the equations are integrated numerically from the shock to the body. The system of equations is integrated simultaneously along each line $I = 1, \dots, N$. The differential equations along any line are coupled to those along the other lines through the finite-difference approximations to the cross derivatives $\partial/\partial\xi$. The equations are integrated by a fourth-order Runge-Kutta method. The accuracy of this method allows the use of relatively large integration steps. The integration step size can generally be taken in increments of -0.1 from the shock to a value of ξ of 0.1 and in increments of -0.05 and -0.025 thereafter. An iterative process based on the Newton method is utilized to adjust the shock shape to satisfy the conditions of flow tangency on the body.



Physical (τ, η) plane



Transformed (ξ, ζ) plane

Sketch (b)

CONICAL-WING GEOMETRY

Three wing shapes – flat plate ($M = 3$), circular arc ($M = 4$), and modified wedge ($M = 5$) – are built into the program and are selected with the use of the body-selection trigger M . It is possible to substitute other wing cross-section shapes with little change in the program provided the wing shape is defined by a function with continuous first and second derivatives. For such wing shapes, the body geometry can be substituted into the logic for the circular-arc wing, and the computation for the new wing shape is found with the body-selection trigger M equal to 4. The changes required for wing shapes with discontinuities in curvature, such as the modified wedge cross section ($M = 5$), are more involved. No description of such changes is given herein, since each shape with curvature discontinuities must be considered individually to insure proper numerical integration for the body geometry.

The compression surface of the conical wing is defined by an equation of the form

$$G(x_o, y_o) = 0$$

where x_o and y_o are the rectangular coordinates of the wing and are related to the Cartesian coordinates X, Y, Z by

$$x_o = X/Z \quad \text{and} \quad y_o = Y/Z$$

The coordinate X is in the spanwise direction, Z is along the axis of the conical wing, and the YZ -plane is the wing plane of symmetry. The windward side of the wing is in the lower half-plane; hence, it should be noted that Y and y_o have negative values there.

The functions required are G_x , G_{xx} , G_y , G_{yy} , and G_{xy} , where the subscripts denote derivatives with respect to the indicated argument. These functions, with their appropriate FORTRAN name, which replace those for the circular-arc wing, are as follows:

G_x (GX(I)), G_{xx} (GXX(I)), and G_y (GY(I)) in cards B3010, B3020, and B3030 of subroutine BG, respectively.

G_{yy} (GYI(I)) and G_{xy} (GXY(I)) in cards B3080 and B3090 of subroutine BG, respectively.

y_o (YOO), G_x (GXI), and G_y (GYI) in cards D500, D510, and D520, of subroutine DERIV, respectively. At this stage x_o is the quantity $F(1)$.

G_x (GXI) and G_y (GYI) in cards D910 and D920 of subroutine DERIV, respectively. At this stage x_0 is F(2) and y_0 is F(3).

APPROXIMATE SHOCK SHAPE FOR CONICAL WINGS

The approximate built-in shock shape for the conical delta wings is generally satisfactory for starting the computations. This shock shape is an even function of ξ which gives both $\eta_s = 0$ and the correct value of $d\eta_s/d\xi$ at the leading edge of the wing. The function is

$$\eta_{s,i} = \left[1 - \left(\frac{\xi_i}{\xi_{N+1}} \right)^2 \right] \left\{ \eta_{s,1} - \left(\frac{\xi_i}{\xi_{N+1}} \right)^2 \left[\eta_{s,1} + \frac{\xi_{N+1}}{2} \left(\frac{d\eta_s}{d\xi} \right)_{N+1} \right] \right\}$$

The value of $\eta_{s,1}$ used in the program is a tangent-cone approximation increased by a factor of 1.2 to avoid the Mach wave conditions for very thin wings at small incidence. In a few computations, the approximate starting value of $\eta_{s,1}$ was so inaccurate that the required corrections $\Delta\eta_{s,i}$ were sizable; thus, a substantial "roughness" in the shock shape resulted and subsequent iterations failed. Even so, the first correction for $\eta_{s,1}$ has been quite good, so that using that value in the approximate shock shape and restarting the program have always been successful. The value of $\eta_{s,1}$, ETAS(1) in FORTRAN notation, is set in cards E710 and E720 of subroutine APPROX.

PROGRAM OPERATION

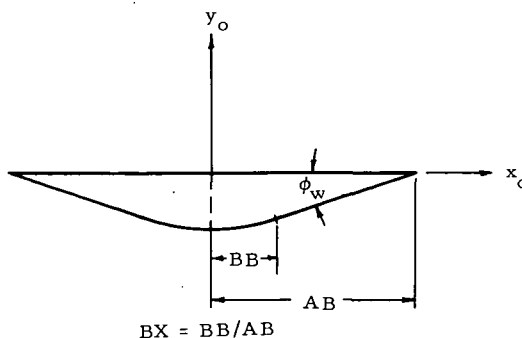
In general, the program operation for the conical-wing computations proceeds with little difficulty and can be made by starting from the built-in approximate shock shape. Instabilities can arise in some cases, and a change in some of the parameters involved will sometimes yield converged solutions. A number of parameters can be adjusted which can affect the convergence and computing time. Some discussion of these parameters is given subsequently with general recommendations for their values.

Input Description

The following list contains the program input variables, which are arranged according to order of presentation in the program.

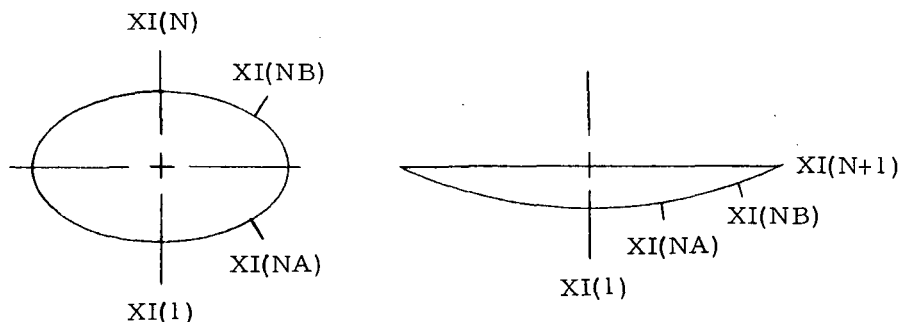
<u>Input card no.</u>	<u>FORTTRAN variable</u>	<u>Description</u>
1	STMACH	Free-stream Mach number, M_∞
2	GAMMA	Ratio of specific heats, γ
	N	<p>Number of lines. Line 1 is in the windward symmetry plane.</p> <p>For conical wings, line $N + 1$ is at the leading edge.</p> <p>For elliptic cones, line N is in the leeward symmetry plane.</p> <p>To obtain force coefficients, N must be an even number for the conical wings and an odd number for the elliptic cones.</p>
	M	<p>Body-selection trigger</p> <p>$M = 0$ for circular cone at zero incidence</p> <p>$M = 2$ for circular and elliptic cones</p> <p>$M = 3$ for windward side of flat-plate wing</p> <p>$M = 4$ for windward side of circular-arc wing</p> <p>$M = 5$ for windward side of modified-wedge wing</p> <p>$M = 1$ and 6 are not operational</p>
	NCASES	<p>Number of cases to be computed in a natural sequence where the converged $\eta_{s,i}$ values for one case are used as the starting values for the next case. NCASES is equal to or greater than one.</p>
	NREAD	<p>Trigger for reading in shock shape</p> <p>$NREAD = 0$ for built-in approximate shock shape. This option is satisfactory for elliptic cones which are nearly circular and small angles of attack.</p> <p>$NREAD = 1$ when input shock shape is to be read in</p>

<u>Input card no.</u>	<u>FORTTRAN variable</u>	<u>Description</u>
2	NSPACE	<p>Line space trigger</p> <p>NSPACE = 1 for equal line spacing</p> <p>NSPACE = 2 gives piecewise constant line spacing in three segments with NA lines in the first segment, (NB-NA) lines in the second segment, and (N-NB) lines in the third segment. This option is not recommended. (See input card no. 6 for further description.)</p>
	NPLOT	<p>Trigger for punched card output used for plotting (see subsection entitled Plots)</p> <p>NPLOT = 0 no punched card output</p> <p>NPLOT = 1 punched card output</p>
	NPUNCH	<p>Punched card output for $\eta_{s,i}$</p> <p>NPUNCH = 0 no punched card output</p> <p>NPUNCH = 1 punched card output for each case</p>
3	This information read in only for M = 5.	
	PHIWD	Wedge angle in the plane $Z = 1$, ϕ_w , degrees (sketch (c))
	BX	<p>Parameter locating x_o coordinate of junction of wedge with circular arc in the plane $Z = 1$. A sharp center ridgeline is approximated by a small value for BX, for example, BX = 0.001. Whenever $BX < XOBAR(2)$ (see section entitled Summary Print Block), line 1 is the only line on the curved segment. In this case, the program sets the body-curvature terms to zero in the differential equations at line 1, but not in the body-geometry equations.</p>



Sketch (c)

<u>Input card no.</u>	<u>FORTTRAN variable</u>	<u>Description</u>
4		This information read in only if NREAD = 1.
	ETAS(I)	Values of $\eta_{s,i}$ which are used to start the computations
5	VTESTHD	Accuracy criterion on maximum normal velocity component at body surface, in which usually a value of 10^{-3} suffices
	VTEST1	Trigger for modified Newton iteration. When the maximum magnitude of the normal velocity component on the surface VMAX lies between VTEST and VTEST1, a modified Newton method (ref. 1) is incorporated where the old Jacobian matrix of influence coefficients is used.
6		This information read in only if NSPACE = 2.
	NA	Number of lines equally spaced in first segment; must be an odd number to obtain force coefficients (sketch (d))
	NB	Line number at end of second segment; must be an odd number to obtain force coefficients
	ANA	For conical wings, $ANA = XI(NA)/XI(N + 1)$. For elliptic or circular cones, $ANA = \frac{XI(NA)}{XI(N)/2}$.
	BNB	For conical wings, $BNB = XI(NB)/XI(N + 1)$. For elliptic or circular cones, $BNB = \frac{XI(NB)}{XI(N)/2}$.



XI is arc length along surface contour.

Sketch (d)

<u>Input card no.</u>	<u>FORTTRAN variable</u>	<u>Description</u>
7		This information read in only if $M = 5$.
	THETAD	The semiangle between the wing leading edge and the Z-axis, θ , degrees
	ALPHAD	Angle of attack, α , degrees
8		This information read in only if $M \neq 5$.
	T	For conical delta wings, T is the ratio of center-line thickness to semispan. For circular and elliptic cones, $T = b/a$, where b is the semiaxis in the YZ-plane of symmetry (which contains the velocity vector) and a is the semiaxis in the XZ-plane of symmetry.
	THETAD	θ , degrees For the conical delta wings, the angle between the wing leading edge and the Z-axis (complement of sweep angle). For the circular and elliptic cones, the cone semiangle in the XZ-plane of symmetry.
	ALPHAD	Angle of attack, α , degrees

Output Description

Among the first items printed are some of the input parameters (see section entitled Input Description), and in addition, some preliminary computed quantities and control parameters (quantities described in the sections entitled Auxiliary Definitions and Secondary Parameters) which are not input data but which can be readily changed within the program. A sample computation is presented in appendix C.

The following output information is printed for each pivotal (trial) shock shape: ETAS(I), ETASP(I), CP(I) (pressure coefficient) at shock, CP(I) at body, and V(I) at body for $I = 1, \dots, N + 1$ for the conical wings and $I = 1, \dots, N$ for the circular and elliptic cones. After the print of V(I) are the values of KCOUNT, VMAX, EPSIG, SPACER, and DETERM, followed by the corrections to the shock shape DETA(I).

After the solution has converged (that is, $V_{MAX} < V_{TESTHD}$, where V_{TESTHD} is V_{TEST} in the sample computation), the full results are printed, starting on a new page, with the input and much of the preliminary information repeated in an orderly fashion. This arrangement allows the printing for the preliminary iterations to be separated and discarded if desired. For conical wing calculations, information relating to the wing leading-edge shock follows this printing. The following quantities, which are measured in a plane normal to the wing leading edge, are printed: $\Delta(N+1)$, $\beta(\text{SONIC})$, $\Delta(\text{SONIC})$, $\beta(\text{DET})$, $\Delta(\text{DET})$, $\beta_{AD}(N+1)$, σ_{AD} , VNS , and AMN . The coordinates of the tip Mach cone X_{MACH} and Y_{MACH} are printed in the next block together with the scaled values X_{MACHB} and Y_{MACHB} which are nondimensionalized by the wing semispan. The summary print block is then printed followed by the arc length $XI(I)$, the body coordinates $XO(I)$ and $YO(I)$, the shock quantities $ETAS(I)$ and $ETASP(I)$, and finally the zeta print blocks.

Windward-line zeta limits. - Following the $ZETA = 0$ print block, the limiting values of certain flow properties which are dependent upon the direction of approach to the nodal-point singularity, as described in reference 1, are printed. The values printed in the $ZETA = 0$ print block are the limits obtained by approaching the symmetry plane along the surface. The limits corresponding to an approach in the symmetry plane are tabulated in the output under the heading WINDWARD LINE ZETA LIMITS. (The entropy function $SBAR$ is printed under the heading labeled S .)

Force coefficients. - After the windward-line zeta limits, the aerodynamic force and moment coefficients are printed as well as the center-of-pressure location. The quantities printed are axial force (CZ), normal force (CY), drag (CD), lift (CL), moment about X-axis (CM), and the coordinates of the center of pressure ($YBAR$ and $ZBAR$). The reference area for the force and moment coefficients is the plan area.

Plots. - The program has a plot-option trigger, $NPLOT$, which can be used to obtain punched card output for use in another program which, in turn, rearranges the cards in an order suitable for plotting cross-flow streamlines, cross-flow sonic lines, and cross sections of the body and shock, as well as surface and shock pressure coefficients, and surface quantities U , W , ρ , and $CROSSM$ as functions of the nondimensional spanwise coordinate, \bar{x} . This second program is not included, however, because each different computer system has its own variations in plotting routines and requirements. It is hoped that the user can adapt the punched card output for these plots to his specific requirements.

Appropriate labels identifying the inputs for the case for which the punched card output is obtained are punched in the MAIN program at cards A1310 and A1320, and the body coordinates, surface quantities, and sonic-line coordinates are punched at cards A6960 to A7070. The quantity $NZETA$ punched at card A6950 in the MAIN program

(computed at card L750 in subroutine PRINT) is a counter of the number of integration steps from the shock and is used in the plotting program. In subroutine PRINT, \bar{x}_s , which is the value of \bar{x} along the shock, and the shock pressure coefficient are punched at cards L540 and L550. The coordinates of the shock and cross-flow streamlines are punched at cards L800 and L810.

Auxiliary Definitions

Several quantities appear in the printout of the preliminary iterations, some of which can be useful in evaluating the sequence of iterations. Several auxiliary quantities that have not been defined elsewhere are defined in the following list:

<u>FORTTRAN variable</u>	<u>Description</u>
AAST	Ratio of critical speed to free-stream speed
AMN	Mach number based on component of stream velocity in a plane normal to wing leading edge
BETA(SONIC)	Shock angle for sonic velocity behind shock, degrees
BETA(DET)	Shock angle for shock detachment at wing leading edge, degrees
BETAD(N+1)	Shock angle at wing leading edge, degrees
DELTA(N+1)	Flow deflection across leading-edge shock measured in a plane normal to wing leading edge, degrees
DELTA(DET)	Flow-deflection angle across shock at detachment condition, degrees
DELTA(SONIC)	Flow-deflection angle across shock for sonic velocity condition, degrees
DETA	Correction applied to each value of η_s , $\Delta\eta$
DETERM	Determinant of the Jacobian, or influence coefficient, matrix (This matrix is normalized so that the sum of squares of the elements of each row is 1.)
EPSIGOM	Parameter for controlling step size during the numerical integration of the body geometry; used in cards C580 and C590 of subroutine RUNKUT and set in card A530 in the MAIN program

<u>FORTTRAN variable</u>	<u>Description</u>
EPSIVAR	Perturbation parameter; changes η_s to $(1 + \text{EPSIVAR})\eta_s$ for each perturbation integration; set in card A2690 of MAIN program and used in cards A8060, A8160, and A8210 of MAIN program
ETASP	Derivative of the quantity η_s with respect to the arc length τ , $d\eta_s/d\tau$
INTCNT	Number of integration steps used to determine $\xi(N)/2$ in body-geometry computation
KCOUNT	Total number of pivotal and variational integrations
NCYCLE	Number of iteration cycles. The first cycle always consists of one pivotal and N variational integrations to generate the Jacobian matrix. Subsequent cycles may or may not include the N perturbation integrations. No perturbation runs are made when $V_{\text{MAX}} < V_{\text{TEST1}}$ (modified Newton computation), and the old Jacobian matrix is used to obtain the corrections $\Delta\eta$. In this case a cycle is one integration. When $V_{\text{MAX}} > V_{\text{TEST1}}$, one cycle consists of the pivotal integration and the N perturbation integrations required to generate a new Jacobian matrix.
PTINF	Free-stream total pressure referenced to product of free-stream density and square of free-stream velocity
RANGLE	Relative angle of incidence for circular and elliptic cones, α/θ_0 , where θ_0 is the cone semiapex angle in the vertical plane of symmetry and α is the angle of attack, degrees (not printed in delta-wing computations)
SIGMAD	Angle between wing and shock at leading edge, degrees
VMAX	Maximum magnitude of normal velocity component on body surface
VNS	Component of unit free-stream velocity in plane normal to wing leading edge
XINI	Arc length to wing leading edge on the intersection of the unit sphere with the wing

Secondary Parameters

A number of secondary parameters which control various computations have been built into the program. Those related to the size of the integration steps are given in the following list:

<u>FORTTRAN variable</u>	<u>Description</u>
EPSIG	Control parameter for triggering the extrapolation to the surface. When the G function in the denominators of the equations for the zeta derivatives becomes smaller than EPSIG, the program extrapolates to obtain values of the normal velocity component at the surface. This parameter is used in cards J960 and J980 of subroutine EQNS and set in card A2660 of the MAIN program. The normal value is 10^{-3} . This parameter must be reduced in value when small integration steps are used near the body.
EPSINT, DSMAX, DSMIN	Parameters used in variable-step integration. Variable-step integration is not recommended for either engineering computations or for computations within the entropy layer. The program uses a fixed-step mode by setting DSMIN=DSMAX in cards K350 and K360 of subroutine RUNKUT2. Value of EPSINT is set in card A2700 of the MAIN program and is used in cards K1250 and K1370 of subroutine RUNKUT2.
SPACER	Sets the minimum distance between points to be used in the formula for extrapolation to body surface. This parameter is used in card K540 of subroutine RUNKUT2 and set in card A2670 of the MAIN program. The recommended value is SPACER=EPSIG.

Summary Print Block

The notation used in the summary print block is as follows:

<u>FORTTRAN variable</u>	<u>Symbol</u>	<u>Description</u>
I		Line number

<u>FORTTRAN variable</u>	<u>Symbol</u>	<u>Description</u>
PSID		Arc tan (y_o/x_o), degrees
PSISD		Arc tan (y_s/x_s), degrees
XO, YO	x_o, y_o	Cartesian coordinates of body in plane $Z = 1$
XOBAR, YOBAR	\bar{x}_o, \bar{y}_o	Cartesian coordinates of body referenced to $x_{o,max}$, where $x_{o,max}$ is the maximum value of x_o
XS, YS	x_s, y_s	Cartesian coordinates of shock in plane $Z = 1$
XSBAR, YSBAR	\bar{x}_s, \bar{y}_s	Cartesian coordinates of shock referenced to $x_{o,max}$
ETAS	η_s	Value of η at shock, radians (see section entitled Zeta Print Blocks for description of η)
BETAD	β	Angle between free-stream velocity vector and tangent plane to shock, degrees
XI	ξ	Arc length along the intersection of the body surface and the unit sphere
CPSHOCK		Pressure coefficient at shock wave
CPBODY		Pressure coefficient at body surface
		Zeta Print Blocks

The notation used in the zeta print blocks is as follows:

<u>FORTTRAN variable</u>	<u>Description</u>
ZETA	Independent variable, η/η_s ; $\xi = 1$ at shock and $\xi = 0$ on body surface
P/ROVSQ	Pressure p referenced to product of free-stream density and square of free-stream velocity
P/ROASTSQ	Pressure referenced to product of free-stream density and square of critical speed
P/PTINF	Pressure referenced to free-stream total pressure
P/PINF	Pressure referenced to free-stream pressure

<u>FORTTRAN variable</u>	<u>Description</u>
RHO	Density ρ referenced to free-stream density
U, V, W	u-, v-, w-components of velocity in r -, η -, τ -directions, respectively, referenced to critical speed
UC, VC, WC	Quasi-cylindrical velocity components in Z-direction, and directions normal and tangential to body contour in plane $Z = 1$, respectively
VCC, WCC	Circular cylindrical components of velocity normal and tangential to a circle in the plane $Z = 1$, referenced to critical speed. UCC is same as UC.
VX, VY, VZ	Cartesian velocity components, referenced to critical speed
PSINOR	Arc tan (VX/VZ) , degrees
THETNOR	Arc cos $\left(VY / \sqrt{(VX)^2 + (VY)^2 + (VZ)^2} \right)$, degrees
XBAR, YBAR	Cartesian coordinates referenced to $x_{o,max}$
XBHLD, YBHLD	Cartesian coordinates, referenced to $x_{o,max}$, of cross-flow streamline (isentropes) that intersects the shock at line I
ETA	Angle measured in a plane normal to the body from ray on surface of body to ray in field, η , radians
G	Function that appears as a factor in the denominator of most of the equations for the ζ -derivatives and which vanishes at the body (g in ref. 1, p. 12)
DEQNS	Function which is a factor in the denominator of the equations for ζ -derivatives (D in ref. 1, p. 13). It vanishes when a line $\zeta = \text{Constant}$ becomes tangent to a conical characteristic. The tangency can occur only when regions of supersonic cross flow ($CROSSM \geq 1$) appear.
AM	Local Mach number, $\frac{\sqrt{u^2 + v^2 + w^2}}{a}$, where a is the speed of sound
CROSSM	Cross-flow Mach number, $\frac{\sqrt{v^2 + w^2}}{a}$

<u>FORTTRAN variable</u>	<u>Description</u>
SBAR	Entropy function, $\bar{S} = \log \left[(P/PINF) \rho^\gamma \right]$
POROGAM	$(P/ROVSQ)/\rho^\gamma$
PT/PTINF	Ratio of total pressure to free-stream total pressure
PT	Total pressure referenced to product of free-stream density and square of free-stream velocity
BERNOUL	Error in Bernoulli equation, $1 - \left(\frac{2\gamma}{\gamma - 1} \frac{p}{\rho} + u^2 + v^2 + w^2 \right)^{\frac{\gamma + 1}{\gamma - 1}}$
DPDZ, DUDZ, DVDZ, DWDZ,DSBDZ	$\frac{dp}{d\xi}, \frac{du}{d\xi}, \frac{dv}{d\xi}, \frac{dw}{d\xi}, \frac{d\bar{S}}{d\xi}$, respectively
PP, UP, VP, WP, SBARP	Finite-difference approximations for $\frac{\partial p}{\partial \tau}, \frac{\partial u}{\partial \tau}, \frac{\partial v}{\partial \tau}, \frac{\partial w}{\partial \tau}, \frac{\partial \bar{S}}{\partial \tau}$, respectively
XBSONIC, YBSONIC	Sonic-line coordinates referenced to wing semispan, $x_{O,max}$

Accuracy Control Parameters

The accuracy of the computations improves with increasing number of lines N and with increasing number of points NP in the cross-derivative approximation formula only within certain limitations. Instabilities can arise for both the elliptic cones and the conical wings, and the instabilities are accentuated for the larger values of N . The integration step size, particularly near the body surface, can also influence the accuracy of the final results. Recommended values for computations to engineering accuracy (three to four figures) are given for the principal parameters.

<u>FORTTRAN variable</u>	<u>Description</u>
DS	Integration step size from shock to body; set in cards K420 to K470 of subroutine RUNKUT2. Recommended values are DS = -0.1 for $0.1 \leq ZETA \leq 1.0$ DS = -0.05 for $0.05 \leq ZETA \leq 0.1$ DS = -0.025 for $0.025 \leq ZETA \leq 0.05$ DS = -0.0125 for $0 \leq ZETA \leq 0.025$

<u>FORTTRAN variable</u>	<u>Description</u>
N	<p>Number of lines</p> <p>For conical wings, $N = 8$ to 14.</p> <p>For circular cones at small incidence ($RANGLE < 0.5$) or elliptic cones of moderate axis ratio ($T \gtrsim 0.7$) and small incidence, $N = 5$ to 11.</p>
NP	<p>Number of points used in computation of cross derivatives; set in cards A680 and A690 in MAIN program</p> <p>NP = 3 for computations where computing time is a prime consideration.</p> <p>NP = 5 for the most computations. Larger values increase the computing time substantially with little change in the overall results. The accuracy with NP = 5 is noticeably better than with NP = 3.</p>
VTESTHD	<p>Convergence criterion on the normal velocity component at the body surface. $VTESTHD = 10^{-3}$ to 10^{-4} for most cases.</p>
VTEST1	<p>Parameter for selection of regular or modified Newton procedure.</p> <p>The modified Newton procedure is used after all the normal velocity components on the body are less than VTEST1. This value is 0.01 to 0.05 for most cases.</p>

Limitations

The limitations of the method are described in detail in reference 1. For the sake of completeness, some of the important points in regard to the delta-wing calculations are repeated here; the elliptic-cone cases are discussed in references 1 and 2.

As stated earlier, this program is restricted to the supersonic flow on the windward side of conical wings without yaw and with shocks attached at the sharp leading edge. An obvious limitation in the angle-of-attack range is that α can not exceed the value corresponding to leading-edge shock detachment and should not be less than the value which corresponds to an expansion on the lower surface. Other limitations are in Mach number and number of lines. All delta-wing cases attempted by the authors with $M_\infty \gtrsim 3$ have been successful. If the Mach number is too low, the shock wave may lie a considerable distance from the surface, and unacceptable error growth may occur, as described in reference 1. Similar instability arises if too many lines are used; 19 lines appear to be the practical maximum in many cases. This maximum is not a severe restriction for the delta wings, since usually the use of eight to 14 lines yields excellent accuracy.

Special System Features

The program makes use of certain features which are special to the Control Data series 6000 computer system at the Langley Research Center, and some changes may be required for other systems. The word length of this computer is 60 bits; consequently, double precision may be required on systems with 32 or 36 bit word lengths. Some seven-character variable names, which may not be acceptable to other systems, have been used in the program. The program is written in FORTRAN IV and requires a field length of 70K₈ to compile and execute on the CDC 6000 series computer system at Langley Research Center.

Langley Research Center,
National Aeronautics and Space Administration,
Hampton, Va., November 23, 1971.

APPENDIX A

REMARKS ON COMPUTATIONS FOR CIRCULAR AND ELLIPTIC CONES

As already mentioned, this program has a limited capability for computing the flow past circular and elliptic cones, but a more efficient version is available for such problems. (See ref. 2.) When the present program is used for such problems, the following remarks should be noted:

(1) Line N lies in the leeward plane of symmetry. (There is no line $N + 1$ as in the wing problems.)

(2) The elliptic cone solutions can be quite sensitive to the accuracy of the shock shape; consequently, they must be developed in incremental steps. A limited provision for this type of computation is provided by the parameter NCASES, where NCASES is the total number of cases in the sequence. Its use allows the converged shock shape for one computation to be used as the initial shock shape for the next computation in the sequence.

For example, to obtain calculations for an elliptic cone with $T = 0.5$, a sequence of calculations starting with a circular cone ($T = 1.0$) and $NREAD = 0$ should be input; subsequent calculations in the sequence should have values of T decreasing in small increments to $T = 0.5$.

APPENDIX B

PROGRAM LISTING, LIST OF SUBROUTINES, AND FLOW CHART

The computational program listing is given in this appendix together with a list of the subroutines and a flow chart.

Program Listing

The computational program listing is as follows:

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C
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PROGRAM MAIN(INPUT,OUTPUT,TAPES=INPUT,PUNCH)
CONICAL FLOW BY THE METHOD OF LINES
COMMON F(3),DF(3),FC(3),DFC(3),AB(3),AB2(3),AB3(3),AB4(3)
COMMON FUN(20,6),DFUN(20,6),FUNC(20,6),DFUNC(20,6),B1(20,6),B2(20,
16),B3(20,6),B4(20,6),SBAR(20,6),DSB0Z(20),SBARP(20),DSB1(20),DSB2(20),
2),DSB3(20),DSB4(20),X(1,20),Y(1,20),VO(1,20),V(1,20),A1(20),A2(20),A3(20),A4(2
AR(20),ASB(20),A7(1,20),AB(20),ANB(20),GX(20),GY(20),GXK(20),GYK(20)
40),GXY(20),ETA(20),ETAS(20),ETASP(20),SETAD(20),RHO(20),R(20),P(20)
5),U(20),V(20),W(20),UP(20),UP(20),VP(20),XS(20),YS(20),Z(20),DUZ(20)
6(20),DP0Z(20),D0VZ(20),D0WZ(20),AM(20),S(20),ZETA(20),ZETA2(20),Z
7),Z(20),ZETA4(20),DU(20),DU2(20),DV3(20),DVM(20),DW(20),DW2(20)
8),DW3(20),DW4(20),DV(20),DV2(20),DV3(20),DVA(20),G(20),PSID(20),DP
9),Z(20),DP2(20),DP3(20),DP4(20),DEONS(20),CROSSM(20),RHOISEN(20),X
COMMON UISEN(20),POROGAM(20),G(20),OP(20),P5150(20),BERNOUL(20),X
1BAR(20),YSBAR(20),XOPAR(20),YOPAR(20),XBAR(20),YBAR(20)
COMMON AAST,B11,B12,B13,B21,B22,B23,NSPACE,P1,M,N,L1,T,T,THETAR,GAMMA
1A,DX1,CN1,CON2,STMACH,AB,A11,A12,A13,A21,A22,A23,A31,A32,A33,ALPH
2AR,N1,NDEBUG,H,HK,SIGMA,RAD,NF,NLINES,EPSI,G,EPISINT,XIN1,SIGNP1
3ND,RHOLEE,RHON,INEXTRAP,EPSIGOM,EPISINT,XIN1,SIGNP1
COMMON XP,X1P,PHIWR,ASBAR,B5,RS,X1BSBAR
COMMON /ERROR/ ER(12),ERR(12),DULK(12)
COMMON VCC(12),VCC(12),SBARHLD(20),XBHLD(20),YBHL(20)
COMMON CP(20),XMACHB(20),YMACHB(20),UC(20),VC(20),WC(20),VX(20),VY
1(20),THETNOR(20),PSINOR(20),POPT1(20),PTOPT1(20),PT(20),POASTSO(20)
2),POPIF(20),XMACH(20),YMACH(20),CPSHOCK(20),CPBODY(20)
3),DIMENSION IDATE(2),ETASO(20),VO(20),D(20,20),B(20,1),PIVOT(2
10),I,DETA(20),XREAL(20),YREAL(20),X1Z(20),Y1Z(20),F1(20),FIB(20),
2 DFI(20,20)
3),DIMENSION DHOLD(20,20)
4),DIMENSION XBSNC(50),YBSNC(50)
5),GOUVALENCE(0,0,DFUN)
COMMON /BLOCK1/ ISTL,NCYCLE,NCOUNT
COMMON /BLOCK2/ NA,NB,ANA,BNB,CNC,KJUNCT
COMMON /BLOCK6/ NEGP
COMMON /BLOCK8/ NCNT
DATA (BLK(1),1,1,12),4HBLK1,4HBLK2,4HBLK3,4HBLK4,4HBLK5,4HBLK6,4HB
1LK7,4HBLK8,4HBLK9,5HBLK10,5HBLK11,5HBLK12/
DATA (ER(1),1,1,12),3HER1,3HER2,3HER3,3HER4,3HER5,3HER6,3HER7,3HER
18,3HER9,4HER10,4HER11,4HER12/
DATA (ERR(1),1,1,12),4HER1,4HER2,4HER3,4HER4,4HER5,4HER6,4HER
18,7,4HER9,4HER10,4HER11,4HER12,3HER12/
CALL DAYTIM(IDATE)
PRINT 111, IDATE
PRINT 110
PRINT 111, IDATE
PRINT 145
PRINT 147
PRINT 147
RAD=57.29577951
PI=3.1415926536
EPSIGOM=.001
PGAM=1.0
NDEBUG=1
ISTL=1
NCNT=0
KTRANSF=1
SLOPF=1.
BX=1.
1 READ (5,106) STMACH,GAMMA
IF (ENDFILE 5) 105,2
2 CONTINUE
NEGP=1
AA5=SQRT((GAMMA-1.)/(GAMMA+1.))+2./((GAMMA+1.)*STMACH**2))
AA5=AA5**2
READ (3,107) N,M,NCASES,NREAD,NSPACE,NPLOT,NPUNCH
IF (N.EQ.1) M=0
IF (N.EQ.2) NP=3
IF (N.EQ.2) NP=5
BODY GEOMETRY INDICES
M=0 ZERO-INCIDENCE CIRCULAR CONE
M=1 *** NOT OPERATIONAL - WINDWARD SIDE OF ELLIPTIC CONE
M=2 CIRCULAR AND ELLIPTIC CONE
M=3 WINDWARD SIDE OF FLAT PLATE WING
M=4 WINDWARD SIDE OF CIRCULAR ARC WING
M=5 MODIFIED WEDGE
M=6 *** NOT OPERATIONAL - WINDWARD SIDE OF PLATE WITH ROUNDED
EDGES
DATA (BLK(1),1,1,12),4HBLK1,4HBLK2,4HBLK3,4HBLK4,4HBLK5,4HBLK6,4HB
1LK7,4HBLK8,4HBLK9,5HBLK10,5HBLK11,5HBLK12/
DATA (ER(1),1,1,12),3HER1,3HER2,3HER3,3HER4,3HER5,3HER6,3HER7,3HER
18,3HER9,4HER10,4HER11,4HER12/
DATA (ERR(1),1,1,12),4HER1,4HER2,4HER3,4HER4,4HER5,4HER6,4HER
18,7,4HER9,4HER10,4HER11,4HER12,3HER12/
CALL DAYTIM(IDATE)
PRINT 111, IDATE
PRINT 110
PRINT 111, IDATE
PRINT 145
PRINT 147
PRINT 147
RAD=57.29577951
PI=3.1415926536
EPSIGOM=.001
PGAM=1.0
NDEBUG=1
ISTL=1
NCNT=0
KTRANSF=1
SLOPF=1.
BX=1.
1 READ (5,106) STMACH,GAMMA
IF (ENDFILE 5) 105,2
2 CONTINUE
NEGP=1
AA5=SQRT((GAMMA-1.)/(GAMMA+1.))+2./((GAMMA+1.)*STMACH**2))
AA5=AA5**2
READ (3,107) N,M,NCASES,NREAD,NSPACE,NPLOT,NPUNCH
IF (N.EQ.1) M=0
IF (N.EQ.2) NP=3
IF (N.EQ.2) NP=5
BODY GEOMETRY INDICES
M=0 ZERO-INCIDENCE CIRCULAR CONE
M=1 *** NOT OPERATIONAL - WINDWARD SIDE OF ELLIPTIC CONE
M=2 CIRCULAR AND ELLIPTIC CONE
M=3 WINDWARD SIDE OF FLAT PLATE WING
M=4 WINDWARD SIDE OF CIRCULAR ARC WING
M=5 MODIFIED WEDGE
M=6 *** NOT OPERATIONAL - WINDWARD SIDE OF PLATE WITH ROUNDED
EDGES
DATA (BLK(1),1,1,12),4HBLK1,4HBLK2,4HBLK3,4HBLK4,4HBLK5,4HBLK6,4HB
1LK7,4HBLK8,4HBLK9,5HBLK10,5HBLK11,5HBLK12/
DATA (ER(1),1,1,12),3HER1,3HER2,3HER3,3HER4,3HER5,3HER6,3HER7,3HER
18,3HER9,4HER10,4HER11,4HER12/
DATA (ERR(1),1,1,12),4HER1,4HER2,4HER3,4HER4,4HER5,4HER6,4HER
18,7,4HER9,4HER10,4HER11,4HER12,3HER12/
CALL DAYTIM(IDATE)
PRINT 111, IDATE
PRINT 110
PRINT 111, IDATE
PRINT 145
PRINT 147
PRINT 147
RAD=57.29577951
PI=3.1415926536
EPSIGOM=.001
PGAM=1.0
NDEBUG=1
ISTL=1
NCNT=0
KTRANSF=1
SLOPF=1.
BX=1.
1 READ (5,106) STMACH,GAMMA
IF (ENDFILE 5) 105,2
2 CONTINUE
NEGP=1
AA5=SQRT((GAMMA-1.)/(GAMMA+1.))+2./((GAMMA+1.)*STMACH**2))
AA5=AA5**2
READ (3,107) N,M,NCASES,NREAD,NSPACE,NPLOT,NPUNCH
IF (N.EQ.1) M=0
IF (N.EQ.2) NP=3
IF (N.EQ.2) NP=5
BODY GEOMETRY INDICES
M=0 ZERO-INCIDENCE CIRCULAR CONE
M=1 *** NOT OPERATIONAL - WINDWARD SIDE OF ELLIPTIC CONE
M=2 CIRCULAR AND ELLIPTIC CONE
M=3 WINDWARD SIDE OF FLAT PLATE WING
M=4 WINDWARD SIDE OF CIRCULAR ARC WING
M=5 MODIFIED WEDGE
M=6 *** NOT OPERATIONAL - WINDWARD SIDE OF PLATE WITH ROUNDED
EDGES

```

APPENDIX B

```

AMN=STACHVNS
IF (N=EO.5) GO TO 9
ANUM=GX(1)*SINTHET*COSETHE*COSALP-GY(1)*SINALP*(XO(1)*GX(1)+YO(1))*
GY(1)*SINTHET**2*COALP
DENOM=SQRT(A2(1))*VNS
IF (DENOM*GT(1.E-10)) GO TO 8
PRINT 114, ER(2),1,VNS,AMN,ANUM,SINTHET,COSTHET,SINALP,COSALP,GX(1)
1),GY(1),XO(1),YO(1),A2(1),DENOM
STOP 0103
8 SINDELN=ANUM/DENOM
DELTAN=ASIN(SINDELN)
GO TO 10
9 PH1WB=ATAN(TAN(PH1WR)/COS(THETAR))
ALPHA=ATAN(TAN(ALPHA1R)/SIN(THETAR))
DELTAN=ALPHA-PH1WB
10 COTANON=1./TAN(DELTAN)
IF (NDEBUG.EQ.0) PRINT 114, BLK(2),1,VNS,AMN,ANUM,DENOM,SINDELN,OE
ILTAN,COTANON,PH1WB,ALPHA
QUAN=1./4.*(GAMMA*AMN**2)
GAMP=GAMMA+QUAN
QUAN=GAMP*(GAMP*AMN**4+8.*(GAMMA-1.)*AMN**2+16.)
QUAN2=GAMP*(GAMP*AMN**4-2.*(3.-GAMMA)*AMN**2+GAMMA+9.)
IF (QUAN1*GT(1.E-20).AND.QUAN2*GT(1.E-20)) GO TO 11
PRINT 114, ER(3),1,QUAN1,QUAN2
STOP 0104
11 SINBD=SQRT(QUAN*(GAMP*AMN**2-1.))+SQRT(QUAN(1))
SINBS=SQRT(QUAN*(GAMP*AMN**2-(3.-GAMMA)+SQRT(QUAN2)))
BETDR=ASIN(SINBD)
BETDR=ASIN(SINBS)
IF (NDEBUG.EQ.0) PRINT 114, BLK(3),1,QUAN,GAMP1,QUAN1,QUAN2,SINBD,
1)SINBS,BETDR,BETSR
COTDET=TAN(BETDR)*(GAMP*AMN**2/(2.*(AMN**2*SIN(BETDR)**2-1.))-1.)-1
1)
COTDSN=TAN(BETSR)*(GAMP*AMN**2/(2.*(AMN**2*SIN(BETSR)**2-1.))-1.)-1
1)
DELTADT=ATAN(1./COTDET)
DELTASN=ATAN(1./COTDSN)
DELTAND=DELTAN*RAD
BETSD=BETSR*RAD
DELTASD=DELTASN*RAD
BETDD=BETDR*RAD
DELTADD=DELTADT*RAD
PRINT 126, DELTAND,BETSD,DELTASD
PRINT 129, BETDD,DELTADD
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7370
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7800
7810
7820
783
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APPENDIX B

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C31=A1*A21-AA2*A31
C32=A1*A22-AA2*A32
C33=A1*A23-AA2*A33
B1GA=A1**2+C31**2-C1**2**2*TAN(AMU)**2
B1GB=A12**2+C32**2-C12**2**2*TAN(AMU)**2
FAC=1./COS(AMU)**2
B1GC=-2.*C11*C12**FAC
B1GD=-2.*C11*C13**FAC
B1GE=-2.*C12*C13**FAC
B1GF=A13**2+C33**2-C13**2**2*TAN(AMU)**2
IF (NDEBUE.EQ.0) PRINT 114, BLK(2),1,ZETA,A21,A22,A23,A31,A32,A33,
IDENOM,A11,A21,U(1),W(1),AMU,AM(1),C11,C12,C13,C31,C32,C33,B1GA,B1G
28,FAC,B1GC,B1GD,B1GE,B1GF
QSQRT=ABS(B1GD**2+4.*B1GA*B1GF)
XDOO=(-B1GD+SQRT(QSQRT))/(2.*B1GA)
YDOO=0.0
DYSOXSO=DYSOX**2
A5=B1GA*B1GB*DYSOXSO+B1GC*DYSOX
B5=-2.*AB*B1GB*DYSOXSO-B1GC*AB*DYSOX+B1GD*B1GE*DYSOX
CS=B1GB*AB**2*DYSOXSO-B1GE*AB*DYSOX+B1GF
QSQRT=ABS(B5**2+4.*A5*CS)
XSHOCK=(-B5+SQRT(QSQRT))/(2.*A5)
YSHOCK=(XSHOCK-AB)*DYSOX
NJ=1
XMACH(1)=XDOO
YMACH(1)=YDOO
XMACHB(1)=XMACH(1)/TAN(THETAR)
YMACHB(1)=YMACH(1)/TAN(THETAR)
IF (NDEBUE.EQ.0) PRINT 114, BLK(3),1,XDOO,YDOO,DYSOXSO,A5,B5,CS,XSHO
CK,YSHOCK,XMACH(1),YMACH(1),XMACHB(1),YMACHB(1)
DO 26 NJ=2,10
ANJ=NJ
YMACH(NJ)=1.*(ANJ-1.)*YSHOCK
BWIG=B1GC*YMACH(NJ)+B1GD
CWIG=B1GB*YMACH(NJ)**2+B1GE*YMACH(NJ)+B1GF
QSQRT=ABS(BWIG**2+4.*B1GA*CWIG)
XMACH(NJ)=(-BWIG+SQRT(QSQRT))/(2.*B1GA)
XMACHB(NJ)=XMACH(NJ)/TAN(THETAR)
YMACH(NJ)=YMACH(NJ)/TAN(THETAR)
IF (NDEBUE.EQ.0) PRINT 114, BLK(4),NJ,YMACH(NJ),BWIG,CWIG,XMACH(NJ
1,XMACHB(NJ),YMACH(NJ)
26 CONTINUE
NJ=1
XMACH(NJ)=XSHOCK

A3420
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A3490
A3500
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A3770
A3780
A3790
A3800
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A3820
A3830
A3840
A3850

:BAR(JJM1)+(X1(JJM1)**2-X1(JJM2)**2)*SBAR(JJ)
X1ST=5*ANUM/DENOM
IF (JJ*NE.2) GO TO 34
X1ST=0.
SBARMX=SBAR(1)
GO TO 35
34 CONTINUE
TERM1=(X1ST-X1(JJM1))*(X1ST-X1(JJ))*SBAR(JJM2)/(X1(JJM2)-X1(JJM1)
1*(X1(JJM2)-X1(JJ)))
TERM2=(X1ST-X1(JJM2))*(X1ST-X1(JJ))*SBAR(JJM1)/(X1(JJM1)-X1(JJM2)
1*(X1(JJM1)-X1(JJ)))
TERM3=(X1ST-X1(JJM2))*(X1ST-X1(JJM1))*SBAR(JJ)/(X1(JJ)-X1(JJM2))*
1*(X1(JJ)-X1(JJM1))
SBARMX=TERM1+TERM2+TERM3
35 PGAM=AA*EXP(SBARMX)
36 IF (NPRINT.EQ.1+AND,NP1V.EQ.0) GO TO 37
GO TO 38
37 PRINT 131, (ETASP(1),1+1,LIMIT)
PRINT 133, (CP(1),1+1,LIMIT)
38 IF (LIMIT.EQ.N) GO TO 39
FUN(LIMIT,2)=U(LIMIT)
FUN(LIMIT,3)=V(LIMIT)
FUN(LIMIT,4)=W(LIMIT)
FUN(LIMIT,5)=W(LIMIT)
FUN(LIMIT,6)=SBAR(LIMIT)
C
C
C
DUMMY INITIALIZATION OF EXTRAPOLATION PARAMETERS
39 DO 40 I=1,N
ZETA1(I)=0.
ZETA2(I)=0.
ZETA3(I)=0.
ZETA4(I)=0.
DUI(1)=0.
DU2(1)=0.
DU3(1)=0.
DU4(1)=0.
DP1(1)=0.
DP2(1)=0.
DP3(1)=0.
DP4(1)=0.
DV1(1)=0.
DV2(1)=0.
DV3(1)=0.

A4300
A4310
A4320
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A4370
A4380
A4390
A4400
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A4470
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A4630
A4640
A4650
A4660
A4670
A4680
A4690
A4700
A4710
A4720
A4730

YMACH(NJ)=YSHOCK
XMACHB(NJ)=XMACH(NJ)/TAN(THETAR)
YMACHB(NJ)=YMACH(NJ)/TAN(THETAR)
POASTSO(1)=P(1)/AASTSO
PQPT(1)=P(1)/PT1NF
PQPTNF(1)=P(1)/GAMMA*STHACH**2
VX(1)=A1*V(1)+A21*W(1)+A31*U(1)
VY(1)=A12*V(1)+A22*W(1)+A32*U(1)
XBAR(1)=A31/(A33+AB)
YBAR(1)=A32/(A33+AB)
QUANZXBAR(1)=A2+YBAR(1)**2
IF (N*NE.2+OR,(M.EQ.3,AND,QUANZ*GT.1.E-07)) GO TO 27
VCC(1)=VX(1)
WCC(1)=VY(1)
GO TO 28
27 RBAR=SQRT(QUANZ)
VCC(1)=XBAR(1)*VX(1)+YBAR(1)*VY(1)/RBAR
WCC(1)=YBAR(1)*VX(1)+XBAR(1)*VY(1)/RBAR
28 PSINOR(1)=ATAN2(VX(1),UC(1))*RAD
THETNOR(1)=ACOS(ABS(VY(1))/SQRT(BUSQ))*RAD
PQPT(1)=PQROGAM(1)/AA**1-1./GAMMA-1.1)
PT(1)=PQPT(1)*PT1NF
29 CP(1)=2.*P(1)-1./GAMMA*STHACH**2
CPSHOCK(1)=CP(1)
30 CONTINUE
IF (NPRINT.EQ.2+AND,(M.EQ.1,OR,M.EQ.6,OR,(M.EQ.2+AND,T.LT.1.0))) G
O TO 31
GO TO 36
31 DO 33 I=1,N
IM1=1
IM2=1-2
IF (1.EQ.1) IM1=2
IF (1.EQ.1) IM2=3
IF (1.EQ.2) IM1=1
IF (1.EQ.2) IM2=2
IF (SBAR(1),LT,SBAR(IM1),AND,SBAR(IM1)+GT,SBAR(IM2)) GO TO 32
GO TO 33
32 JJ=1
JJM1=IM1
JJM2=IM2
33 CONTINUE
DENOM=X1(JJ)-X1(JJM1))*SBAR(JJM2)-(X1(JJ)-X1(JJM2))*SBAR(JJM1)+(X
1(JJM1)-X1(JJM2))*SBAR(JJ)
ANUM=(X1(JJM1)**2-X1(JJ)**2)*SBAR(JJM2)-(X1(JJ)**2-X1(JJM2)**2)*S
A3860
A3870
A3880
A3890
A3900
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A3920
A3930
A3940
A3950
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A3970
A3980
A3990
A4000
A4010
A4020
A4030
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A4070
A4080
A4090
A4100
A4110
A4120
A4130
A4140
A4150
A4160
A4170
A4180
A4190
A4200
A4210
A4220
A4230
A4240
A4250
A4260
A4270
A4280
A4290

DV4(1)=1.0
DW1(1)=1.0
DW2(1)=1.0
DW3(1)=1.0
DW4(1)=1.0
DSB1(1)=1.0
DSB2(1)=1.0
DSB3(1)=1.0
DSB4(1)=1.0
40 CONTINUE
NZET1=0
NPF=6
ZETA=1.0
DZETA=-1
DO 41 I=1,N
FUN(1,1)=ZETA
FUN(1,2)=U(1)
FUN(1,3)=P(1)
FUN(1,4)=V(1)
FUN(1,5)=W(1)
FUN(1,6)=SBAR(1)
DFUNC(1,1)=DZETA
FUNC(1,2)=U(1)
41 CONTINUE
C
C
C
INTEGRATE EQUATIONS FROM ZETA=1 TO ZETA=0
DO 72 INCNT=1,100000
CALL DERIV2 (DZETA,NB)
IF (NEGP.EQ.0+AND,NPRINT.EQ.1) GO TO 73
IF (NEGP.EQ.0+AND,NPRINT.EQ.2+AND,L1.EQ,NCASES) GO TO 104
IF (NEGP.EQ.0+AND,NPRINT.EQ.2+AND,L1.NE,NCASES) STOP 7776
42 IF (NPRINT.NE.2) GO TO 66
NZET1=NZET1+1
DO 43 I=1,N
ZETA=FUN(1,1)
U(1)=FUN(1,2)
P(1)=FUN(1,3)
V(1)=FUN(1,4)
W(1)=FUN(1,5)
SBAR(1)=FUN(1,6)
DZETA=DFUNC(1,1)
DUZ(1)=DFUNC(1,2)
DPOZ(1)=DFUNC(1,3)
A4740
A4750
A4760
A4770
A4780
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A4800
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A4970
A4980
A4990
A5000
A5010
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A5100
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A5160
A5170

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APPENDIX B

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DWDZ(1)=DFUN(1.4)
DWDZ(2)=DFUN(1.5)
DSDZ(1)=DFUN(1.6)
43 CONTINUE
IF (M.EQ.3.OR.M.EQ.4.OR.M.EQ.5) PGAM=POROGAM(N+1)
UW=U(1)
RHOW=RHO(1)
SW=SBAR(1)
POROGAM=POROGAM(1)
UL=U(N)
RHOW=RHO(N)
SL=SBAR(N)
POROGAM=POROGAM(N)
IF (M.EQ.3.OR.M.EQ.4.OR.M.EQ.5) GO TO 44
IF (T.EQ.1.) PGAM=POROGAM
W(1)=0.
W(N)=W(1)
44 IF (M.EQ.0) GO TO 60
IF (ZETA.NE.0.0) GO TO 60
C
C COMPUTATION OF CORRECTED SURFACE VALUES
C
EPSISEN=1.E-07
TERM1=(1.+2./(GAMMA-1.)*STMACH**2)/AASTSO
FAC=(2.*GAMMA)/(GAMMA-1.)*AASTSO
DO 47 I=1,N
IF (T.GT.1.) GO TO 45
RHO(1)=(P(1)/PGAM)**GAMX
GO TO 46
45 IF (W(1).GE.0.) RHO(1)=(P(1)/POROGAM)**GAMX
IF (W(1).LT.0..OR.1.EQ.0) RHO(1)=(P(1)/POROGAM)**GAMX
46 U(1)=SORT(TERM1-FAC*P(1)/RHO(1)-W(1)**2)
47 CONTINUE
EPSIU=1.E-08
GO TO 56
48 DO 49 I=1,N
FIB(1)=TERM1-FAC*P(1)/RHO(1)-U(1)**2-UP(1)**2
49 UISEN(1)=U(1)
DO 52 J=1,N
I=J
50 U(J)=(1.+EPSIU)*UISEN(J)
CALL LGRANGE (M,1,NP,NLINES,NLINEP,NDEBUG,X(1),X1,U,X,Y,DYDX)
UP(1)=DYDX
F(1)=TERM1-FAC*P(1)/RHO(1)-U(1)**2-UP(1)**2
51 U(J)=UISEN(J)
52 CONTINUE
DO 53 I=1,N
B(1,1)=FIB(1)
53 NM1=N-1
CALL SIMEQ (DFIDU,NB,1,0,TERM,IP1,VOT,NMAX,ISCALE)
DO 54 I=1,N
U(1)=UISEN(1)+B(1,1)
DO 55 I=1,N
IF (ABS(B(1,1)).GT.EPSISEN) GO TO 56
55 CONTINUE
GO TO 58
56 DO 57 I=1,N
CALL LGRANGE (M,1,NP,NLINES,NLINEP,NDEBUG,X(1),X1,U,X,Y,DYDX)
57 UP(1)=DYDX
GO TO 48
58 DO 59 I=1,N
W(1)=UP(1)
POROGAM(1)=P(1)/RHO(1)**GAMMA
SBAR(1)=ALOG(GAMMA*STMACH**2*POROGAM(1))
DENOM=SBAR(1)/RHO(1)
CROSSM(1)=ABS(W(1))/DENOM*AAST
ASO=GAMMA*FUN(1,3)/RHO(1)
BUSO=U(1)**2+V(1)**2+W(1)**2
AM(1)=SORT(AAST**2*BUSO/ASO)
DENOM1=2./(GAMMA-1.)*STMACH**2
BERNOUL(1)=1.-(2.*GAMMA*FUN(1,3)/RHO(1)*(GAMMA-1.))+BUSO*AAST**2)
1/DENOM
ASO=GAMMA*FUN(1,3)/RHO(1)
AISO=ASO/AASTSO
WOA=W(1)**2/AISO
DWDZ(1)=ETAS(1)*(1.-WOA)*W(1)+U(1)*(2.-WOA)
DPDZ(1)=ETAS(1)*RHO(1)*HK*W(1)**2*AASTSO
59 CONTINUE
C
C COMPUTE SPECIAL QUANTITIES FOR PRINTOUT
C
DO 60 I=1,N
IF (ZETA.EQ.0.0) ETA(1)=0.0
CON1=SIN(ETA(1))

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APPENDIX B

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IF (NPLOT.EQ.0) GO TO 76
PUNCH 107, NZETA
PUNCH 123, (XBAR(I),I=1,LIMIT)
PUNCH 123, (YBAR(I),I=1,LIMIT)
IF (M.EQ.2) PUNCH 123, (PSID(I),I=1,LIMIT)
IF (M.EQ.2) PUNCH 123, (XBAR(I),I=1,LIMIT)
PUNCH 123, (CPBODY(I),I=1,LIMIT)
PUNCH 123, (U(I),I=1,LIMIT)
PUNCH 123, (W(I),I=1,LIMIT)
PUNCH 123, (RHO(I),I=1,LIMIT)
PUNCH 123, (CROSSM(I),I=1,LIMIT)
IF (M.EQ.2) GO TO 76
PUNCH 123, (XBSNC(I),I=1,NZETI)
PUNCH 123, (YBSNC(I),I=1,NZETI)
76 PRINT 138
PRINT 137
PRINT 136, UM, RHO, SM, PORGAM, UCM, VCM, WCM, VXM, VYM, VZW, PTOPTIW
IF (M.EQ.2) GO TO 77
PRINT 137
PRINT 139
PRINT 137
PRINT 136, UL, RHO, SL, PORGAM, UCL, VCL, WCL, VXL, VYL, VZL, PTOPTIL
77 IF (NPV.EQ.0) PRINT 134, (CP(I),I=1,LIMIT)
IF (NPV.EQ.0) PRINT 120, (FUN(I,4),I=1,LIMIT)
C
INTSTEP - TOTAL NUMBER OF GOOD INTEGRATION STEPS
C
INTSTEP=INTSTEP+INTCNT
IF (NPRINT.NE.2) GO TO 78
IF (M.EQ.0.OR.M.EQ.1.OR.M.EQ.6) GO TO 104
C
FORCE AND MOMENT COEFFICIENTS
C
IF (MOD(LIMIT,2).EQ.0.OR.MOD(MA,2).EQ.0.OR.MOD(NB,2).EQ.0) GO TO 1
104 CALL FMCOEF (LIMIT,NA,NB,NSPACE,XI,A,M,AA,AAA,P,A2,A1,A4,GY,YO,S)
INALP,COSALP)
C
TESTS FOR CONVERGENCE
C
78 IF (NCOUNT.NE.0) GO TO 85
VTEST=VTESTHD
DO 79 I=1,N
IF (I.EQ.1) VMAX=ABS(FUN(I,4))
IF (ABS(FUN(I,4)).GT.VMAX) VMAX=ABS(FUN(I,4))
A6940 KCOUNT=KCOUNT+1
A6950 NPV=NPV+1
A6960 IF (NCYCLE.GT.50) STOP 0777
A6970 IF (NCOUNT.GT.1) GO TO 89
A6980 DO 80 I=1,N
A6990 VO(I)=FUN(I,4)
A7000 IF (I.EQ.1) VMAX=ABS(VO(I))
A7010 IF (ABS(VO(I)).GT.VMAX) VMAX=ABS(VO(I))
A7020 87 ETASO(I)=ETAS(I)
A7030 IF (NPV.EQ.1.AND.N.EQ.1) PRINT 124, KCOUNT,VMAX,EPSIG,SPACER,EP
A7040 IVAR
A7050 IF (NPV.EQ.1.AND.N.EQ.1) GO TO 88
A7060 IF (NPV.EQ.2) GO TO 88
A7070 IF (NPRINT.EQ.1.AND.NPV.EQ.1) PRINT 124, KCOUNT,VMAX,EPSIG,SPACER
A7080 I=EPSIVAR
A7090 IF (NPRINT.EQ.1.AND.NSKIP.EQ.1) PRINT 124, KCOUNT,VMAX,EPSIG,SPACE
A7100 IR=EPSIVAR
A7110 IF (NSKIP.EQ.1) GO TO 93
A7120 IF (EPSIG.EQ.EPSIGMX) GO TO 88
A7130 NCOUNT=0
A7140 GO TO 18
A7150 C
A7160 C BEGIN ETAS(I) VARIATION
A7170 C
A7180 C
A7190 88 ETAS(J+1)=ETAS(J)+*(1+EPSIVAR)
A7200 GO TO 18
A7210 89 J=J+1
A7220 IF (M.NE.1) GO TO 90
A7230 C
A7240 C COMPUTE DETA FOR TAYLOR-MACCOLL
A7250 C
A7260 C DETA(I)=EPSIVAR*ETASO(I)/(1-FUN(I,4)/VO(I))
A7270 GO TO 102
A7280 90 IF (J.LT.N) ETAS(J+1)=ETAS(J)+*(1+EPSIVAR)
A7290 ETAS(J)=ETASO(J)
A7300 C
A7310 C COMPUTE ELEMENTS OF JACOBIAN MATRIX
A7320 C
A7330 C DO 91 I=1,N
A7340 D(I,J)=FUN(I,4)-VO(I)/(EPSIVAR*ETASO(J))
A7350 DMOLD(I,J)=D(I,J)
A7360 91 CONTINUE
A7370 IF (J.EQ.N) GO TO 92
GO TO 18
A8260
A8270
A8280
A8290
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APPENDIX B

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106 FORMAT (5E14.8)
107 FORMAT (10I5)
108 FORMAT (8H STWACH=E16.8,2X,6HGAMMA=E16.8,2X,ZHT=E16.8,2X,7HTHETAD=
E16.8,2X,7HALPHAD=E16.8/)
109 FORMAT (3H N=12,2X,2HNA=11,2X,6HNSREAD=11,2X,7HNSPACE=11,2X,3HNP=12)
110 FORMAT (1H1//)
111 FORMAT (2A10//)
112 FORMAT (/)
113 FORMAT (9H EPSIGOM=E16.8)
114 FORMAT (1XIA6.15/(8E16.8))
115 FORMAT (215,2E16.8)
116 FORMAT (4H NA=12,2X,4HANA=E16.8,2X,3HNB=12,2X,4HNB=E16.8/)
117 FORMAT (8H INTCNT=15,2X,8HNEXTAP=11)
118 FORMAT (/40X,5H2ETA=E16.8/)
119 FORMAT (/29H ZERO=INCIDENCE CIRCULAR CONE//)
120 FORMAT (2H V/(1X8E16.8))
121 FORMAT (5H DELTA/(1X8E16.8))
122 FORMAT (5H ETAS/(8E16.8))
123 FORMAT (5E16.8)
124 FORMAT (8H KCOUNT=15,2X,5HVMAX=E16.8,2X,6HEPSIG=E16.8,2X,7HSPACER=
E16.8,2X,8HEPSIVAR=E16.8)
125 FORMAT (6H AAST=E16.8,2X,6HPTINF=E16.8/)
126 FORMAT (3H T=E16.8,2X,7HTHETAD=E16.8,2X,7HALPHAD=E16.8,2X,2HM=12)
127 FORMAT (7H VTEST=E16.8,2X,7HVTST=E16.8)
128 FORMAT (12H DELTA(N+)=E16.8,2X,13H BETA(SONIC)=E16.8,2X,13HDELTA(
1SONIC)=E16.8)
129 FORMAT (20X,10HBETA(2ET)=E16.8,5X,11HDELTA(2ET)=E16.8)
130 FORMAT (40H FLOW DETACHED FROM LEADING EDGE OF WING)
131 FORMAT (6H ETASP/(8E16.8))
132 FORMAT (12H BETAD(N+)=E16.8,2X,7HSGNAD=E16.8,2X,4HVN=E16.8,2X,4
1HVMN=E16.8)
133 FORMAT (15H CP(1) AT SHOCK/(8E16.8))
134 FORMAT (16H CP(1) AT ZETA=0/(8E16.8))
135 FORMAT (4H NJ=12,2X,6HGMACH=E16.8,2X,6HVMACH=E16.8,2X,7HGMACHB=E16
1.8,2X,7HVMACHB=E16.8)
136 FORMAT (11E12.4)
137 FORMAT (13H U RHO VX S POROGAM VZ U
1C VC WC VV VY VZ U
2 PT/PTINF /)
138 FORMAT (/72H WINDW
1RD LINE ZETA LIMIT/)
139 FORMAT (/71H LEEWAR
1D LINE ZETA LIMIT/)
140 FORMAT (315,2E16.8)

141 FORMAT (4H NA=12,2X,3HNB=12,2X,7HKNJUNCT=12,2X,4HANA=E16.8,2X,4HCNC
1=E16.8)
142 FORMAT (/8H RANGLE=E16.8/)
143 FORMAT (/9H XBSONIC=E16.8,2X,8HYBSONIC=E16.8/)
144 FORMAT (1H1,40H DAVIS - A218081 FINISHED COMPUTING AT ,2A10)
145 FORMAT (/44H DAVIS-DLO-A218081-APPLIED MECHANICS-8-13-68)
146 FORMAT (27H BERNIE KLUNKER-JERRY SOUTH)
147 FORMAT (36H CONICAL FLOW BY THE METHOD OF LINES//)
148 FORMAT (1X8E16.8)
149 FORMAT (7H D(1,J))
150 FORMAT (/8H NCYCLE=12,6H AT ,2A10/)
151 FORMAT (7H PHIND=E16.8,2X,3HXB=E16.8)
152 FORMAT (8H ISCALE=15,2X,7HSDTERM=E16.8)
153 FORMAT (/27H CHECK FOR SHOCK DETACHMENT/)
154 FORMAT (8H NCYCLE=12,2X,6HNSSTEP=12,2X,6HVTST=E16.8,2X,5HVMAX=E16.
18,2X,5HAASST=E16.8,2X,6HPTINF=E16.8/)
END
SUBROUTINE BG
C
C BODY GEOMETRY
C
COMMON F(3),DF(3),PC(3),DFC(3),AB1(3),AB2(3),AB3(3),AB4(3)
COMMON FUN(20,6),DFUNC(20,6),FUNG(20,6),DFUNC(20,6),B1(20,6),B2(20,
16),B3(20,6),B4(20,6),SBAR(20),DSBDZ(20),SBARP(20),DSB1(20),DSB2(20
2),DSB3(20),DSB4(20),X1(20),X0(20),Y0(20),A1(20),A2(20),A3(20),A4(2
30),A5(20),A6(20),A7(20),A8(20),A9(20),GX(20),GY(20),GX(20),GY(2
40),GVY(20),ETA(20),ETAS(20),ETASP(20),BETAD(20),RHO(20),R(20),P(20
5),U(20),V(20),W(20),UP(20),VP(20),WP(20),XS(20),YS(20),DUDZ
6(20),DPOZ(20),DVOZ(20),DWDZ(20),AM(20),S(20),ZETA1(20),ZETA2(20),Z
7ETA3(20),ZETA4(20),DU1(20),DU2(20),DU3(20),DU4(20),DU1(20),DU2(20)
8-DW1(20),DW2(20),DW3(20),DW4(20),DVS(20),DVS(20),G(20),PSID(20),DP
9(20),DP2(20),DP3(20),DP4(20),DEONS(20),CROSSM(20),RHOISEN(20)
COMMON UISEN(20),POROGAM(20),G(20),GP(20),PSID(20),BERNOUL(20),XS
1BAR(20),YSBAR(20),XGBAR(20),YGBAR(20),XGBAR(20),YGBAR(20)
COMMON AAST,B1,B2,B3,B21,B22,B23,NSPACE,P1,M,N,L,T,THETAR,GAMM
1A,DK1,CON1,CON2,STWACH,AB,A1,A12,A13,A21,A22,A23,A31,A32,A33,ALPH
2AR,N1,NDEBUG,H,HK,S,IGNA,RAD,NF,NLINES,EP SIG,NPRINT,SPACER,U,LEE,UW1
3ND,RHOLEE,RHOWIND,NEXTAP,EP SIGOM,EP SIGINT,XIN1,SIGNP1
COMMON XP,XIP,PHIWR,SBAR,BS,RS,XISBAR
COMMON /ERROR/ ER(12),ERR(12),BLK(12)
COMMON VCC(20),WCC(20),SBARHLD(20),XBHLD(20),YBHLD(20)
COMMON CP(20),XMACB(20),YMACB(20),UC(20),VC(20),WC(20),VX(20),VY
1(20),THETNOR(20),PSINOR(20),POPT1(20),PTOPT1(20),PT(20),POASTSQ(20
2),POPIN(20),XMACH(20),YMACH(20),CPSHOCK(20),CPBODY(20)
A8700 COMMON /BLOCK2/ NA,NB,ANA,BNB,CNC,KJUNCT
A8710 NOEBUG=1
A8720 INTIO=40
A8730 XISBAR=1.
A8740 IF (M.NE.4) GO TO 1
A8750 AC=(1.-T**2)/(2.*T)
A8760 ACC=AC/TAN(THETAR)
A8770 RC=TAN(THETAR)*(1.+T**2)/(2.*T)
A8780 1 NLINEP1=NLINES+1
A8790 LIMIT=N
A8800 IF (M.EQ.3.OR.M.EQ.4.OR.M.EQ.5) LIMIT=NLINEP1
A8810 NF=2
A8820 AB=TAN(THETAR)
A8830 IF (M.EQ.5) YWIG=RS*CS(1)PHIWR+TAN(1)PHIWR*(SBAR-AB)
A8840 XP=(1.-T)*AB
A8850 C
A8860 C BODY SELECTION
A8870 C
A8880 IF (M.EQ.0) GO TO 2
A8890 IF (M.EQ.1.OR.M.EQ.2.OR.M.EQ.4.OR.M.EQ.5) GO TO 8
A8900 IF (M.EQ.3) GO TO 3
A8910 IF (M.EQ.6) GO TO 45
A8920 C
A8930 C TAYLOR-MACCOLL
A8940 C
A8950 2 I=1
A8960 X(1)=0.0
A8970 X(1)=0.0
A8980 Y(1)=0.0
A8990 GX(1)=2.*X(1)
A9000 GY(1)=2.*Y(1)
A9010 GX(1)=2.
A9020 GY(1)=2.
A9030 GXY(1)=0.0
A9040 IF (NOEBUG.EQ.0) PRINT 75, 1,X(1),X(1),Y(1)
A9050 IF (NOEBUG.EQ.0) PRINT 74, 1,GX(1),GY(1),GX(1),GY(1),GXY(1)
A9060 GO TO 54
A9070 C
A9080 C FLAT PLATE - M=3
A9090 C
A9100 3 X(IN1)=THETAR
A9110 DO 4 I=1,NLINEP1
A9120 Y(1)=0.0
A9130 GX(1)=0.0
A9140 GY(1)=0.0
A9150 GX(1)=0.0
A9160 GY(1)=0.0
A9170 4 CONTINUE
A9180 XIN1=X(IN1)
A9190 IF (NOEBUG.EQ.0) PRINT 79, BLK(1),X(IN1),Y(1),GX(1),GY(1),GXY(1)
A9200 1,GY(1),1,NLINEP1
A9210 GO TO 14
A9220 C
A9230 C CIRCULAR ARC- M=4
A9240 C
A9250 5 NINT=3
A9260 NF=2
A9270 TANTHET=TAN(THETAR)
A9280 DO 6 INTENT=1,100000
A9290 CALL DERIV (ACC,RC,THETAR,NINT,NCHANGE,NOEBUG,T,AB,F,DF,NF,XIN
1,XIN,XP,RS,PHIWR,XISBAR,YWIG,SBAR)
A9300 CALL RUNKUT (ACC,RC,THETAR,NINT,NCHANGE,NSTEP,NOEBUG,T,AB,F,DF,PC
1,DFC,DS,AB1,AB2,AB3,AB4,NF,EP SIGOM,NOUAD,X00,XIN1,XIN,XP,RS,PHIWR,X
2ISBAR,YWIG,SBAR)
A9310 IF (ABS(F(1))-TANTHET)*LE+1.E-07) GO TO 7
A9320 IF (F(1)+DF(1),LT,TANTHET,AND,ABS(TANTHET-F(1))-DF(1),GT,1.E-07) G
10 TO 6
A9330 DS=TANTHET-F(1)
A9340 DF(1)=DS
A9350 6 CONTINUE
A9360 7 X(IN1)=F(2)
A9370 GO TO 13
A9380 C
A9390 C ELLIPTIC CONE- M=2
A9400 C
A9410 8 NSTEP=2
A9420 C CIRCULAR AND ELLIPTIC CONE - COMPUTATION OF X(IN1)
A9430 NINT=1
A9440 NCHANGE=1
A9450 NGUAD=1
A9460 F(1)=0.0
A9470 F(2)=0.0
A9480 DS=0.1*AB
A9490 DF(1)=DS
A9500 X00=0.0
A9510 IF (M.EQ.4) GO TO 5
A9520 IF (M.EQ.5) NINT=7
A9530 C

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APPENDIX B

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C      INTEGRATION WITH XO OR YO INDEPENDENT VARIABLE - NINT=1      B1150
C      INTEGRATION OVER XO - NCHANGE=1, VARIABLE STEP - NSTEP=2      B1160
C      B1170
CHECK1=AB/SORT(1.+T**2)
CHECK2=-T**2*AB/SORT(1.+T**2)
CHECK3=0.0
IF (M.EQ.5) CHECK1=B*BAR
IF (DS.GT.CHECK1) DS=.5*CHECK1
DF(1)=DS
IF (M.EQ.5) CHECK3=AR
DO 12 INTCONT=1,100000
CALL DERIV (ACC,RC,THETAR,NINT,NCHANGE,NDEBUG,T,AB,F,DF,NF,XOO,XIN
11,XIN,XP,RS,PHIWR,XIBSBAR,YWIG,BBAR)
IF (NCHANGE.EQ.2.AND.ABS(F(1))-CHECK3).LE.1.E-10) GO TO 13
CALL RUNKUT (ACC,RC,THETAR,NINT,NCHANGE,NSTEP,NDEBUG,T,AB,F,DF,FC,
10FC,DS,AB1,AB2,AB3,AB4,NF,EPSIGOM,NOUAD,XOO,XINI,XIN,XP,RS,PHIWR,X
2IBSBAR,YWIG,BBAR)
IF (INTCONT.EQ.1) DS0AB=DS/AB
IF (NDEBUG.EQ.0) PRINT 76, INTCONT
IF (NCHANGE.EQ.1.AND.(F(1)+DF(1)).LE.CHECK1.AND.CHECK1-F(1)+DF(1)
1).GT.1.E-07) GO TO 12
IF (NCHANGE.EQ.1.AND.(F(1)+DF(1)).LE.CHECK1.AND.CHECK1-F(1)+DF(1)
1).LE.1.E-07) GO TO 9
IF (NCHANGE.EQ.1.AND.(F(1)+DF(1)).GT.CHECK1) GO TO 9
IF (NCHANGE.EQ.2.AND.(F(1)+DF(1)).LE.CHECK3.AND.ABS(F(1)+DF(1))-CHE
1CK3).GT.1.E-07) GO TO 12
IF (NCHANGE.EQ.2.AND.(F(1)+DF(1)).LE.CHECK3.AND.ABS(F(1)+DF(1))-CHE
1CK3).LE.1.E-07) GO TO 11
IF (NCHANGE.EQ.2.AND.(F(1)+DF(1)).GT.CHECK3) GO TO 11
9 DS=CHECK1-F(1)
DF(1)=DS
GO TO 12
C
C      INTEGRATION OVER YO - NCHANGE=2, VARIABLE STEP - NSTEP=2
C
10 NCHANGE=2
IF (NINT.EQ.7) XIBSBAR=F(2)
IF (NINT.EQ.7) XOBBSBAR=F(1)
IF (NINT.EQ.1) F(1)=CHECK2
DS=0.1*AB
DF(1)=DS
GO TO 12
11 DS=CHECK3-F(1)
B1180
B1190
B1200
B1210
B1220
B1230
B1240
B1250
B1260
B1270
B1280
B1290
B1300
B1310
B1320
B1330
B1340
B1350
B1360
B1370
B1380
B1390
B1400
B1410
B1420
B1430
B1440
B1450
B1460
B1470
B1480
B1490
B1500
B1510
B1520
B1530
B1540
B1550
B1560
F(2)=XO(1)
F(3)=YO(1)
IF (M.EQ.5.AND.DX1.GT.XIBSBAR) DX1=.5*XIBSBAR
DX1HL=DX1
DF(1)=DX1
IF (M.EQ.5) GO TO 23
DO 22 IZ=2,LIMIT
DO 19 I=2,100000
CALL DERIV (ACC,RC,THETAR,NINT,NCHANGE,NDEBUG,T,AB,F,DF,NF,XOO,XIN
11,XIN,XP,RS,PHIWR,XIBSBAR,YWIG,BBAR)
CALL RUNKUT (ACC,RC,THETAR,NINT,NCHANGE,NSTEP,NDEBUG,T,AB,F,DF,FC,
10FC,DX1,AB1,AB2,AB3,AB4,NF,EPSIGOM,NOUAD,XOO,XINI,XIN,XP,RS,PHIWR,
2XIBSBAR,YWIG,BBAR)
IF (NDEBUG.EQ.0) PRINT 72, I,F(1),F(2),F(3)
IF (ABS(F(1)-X1(IZ)).LE.1.E-10) GO TO 20
IF (F(1)+DF(1)).LE.X1(IZ).AND.X1(IZ)-F(1)+DF(1).GT.1.E-07) GO T
10 19
DX1HL=DX1
DX1=X1(IZ)-F(1)
DF(1)=DX1
19 CONTINUE
20 IF (NSPACE.EQ.1) DX1=DX1HL
IF (NSPACE.EQ.1) DF(1)=DX1
IF (NSPACE.EQ.1) GO TO 21
IF (F(1).GE.X1(NB).AND.F(1).LT.X1(NB)) DX1=ABB/FLOAT(INTIO)
IF (F(1).GE.X1(NB).AND.F(1).LE.X1(N)) DX1=AN/FLOAT(INTIO)
IF (NDEBUG.EQ.0) PRINT 78, DX1
DF(1)=DX1
21 X1(IZ)=F(1)
XO(IZ)=F(2)
YO(IZ)=F(3)
IF (NDEBUG.EQ.0) PRINT 73, IZ,X1(IZ),XO(IZ),YO(IZ)
22 CONTINUE
GO TO 34
C
C      CALCULATION OF BODY GEOMETRY FOR MODIFIED WEDGE - M=5
C
23 DO 31 IZ=2,LIMIT
DO 28 I=2,100000
CALL DERIV (ACC,RC,THETAR,NINT,NCHANGE,NDEBUG,T,AB,F,DF,NF,XOO,XIN
11,XIN,XP,RS,PHIWR,XIBSBAR,YWIG,BBAR)
CALL RUNKUT (ACC,RC,THETAR,NINT,NCHANGE,NSTEP,NDEBUG,T,AB,F,DF,FC,
10FC,DX1,AB1,AB2,AB3,AB4,NF,EPSIGOM,NOUAD,XOO,XINI,XIN,XP,RS,PHIWR,
2XIBSBAR,YWIG,BBAR)
IF (NDEBUG.EQ.0) PRINT 72, I,F(1),F(2),F(3)
IF (ABS(F(1)-X1(IZ)).LE.1.E-10) GO TO 29
IF (F(1)+DF(1)).LE.X1(IZ).AND.ABS(X1(IZ)-F(1)+DF(1)).GT.1.E-07) GO
10 27
IF (F(1)+DF(1)).LE.X1(IZ).AND.ABS(X1(IZ)-F(1)+DF(1)).LT.1.E-07) GO
10 27
IF (F(1)+DF(1)).GT.X1(IZ) GO TO 27
24 IF (NCHANGE.EQ.2) GO TO 28
IF (NCHANGE.EQ.1.AND.ABS(XIBSBAR-F(1)).LE.1.E-10) GO TO 25
IF (NCHANGE.EQ.1.AND.F(1)+DF(1).LT.XIBSBAR.AND.ABS(XIBSBAR-F(1))-DF
1(1)).GT.1.E-07) GO TO 28
IF (NCHANGE.EQ.1.AND.F(1)+DF(1).LT.XIBSBAR.AND.ABS(XIBSBAR-F(1))-DF
1(1)).LT.1.E-07) GO TO 26
IF (NCHANGE.EQ.1.AND.F(1)+DF(1).GT.XIBSBAR) GO TO 26
25 NCHANGE=2
DX1=DX1HL
DF(1)=DX1
GO TO 28
26 DX1HL=DX1
DX1=XIBSBAR-F(1)
DF(1)=DX1
GO TO 28
27 DX1HL=DX1
DX1=X1(IZ)-F(1)
DF(1)=DX1
28 CONTINUE
29 DX1=DX1HL
DF(1)=DX1
IF (NSPACE.EQ.1) GO TO 30
IF (IZ.GE.NA.AND.IZ.LT.NB) DX1=ABB/FLOAT(INTIO)
IF (IZ.GE.NB.AND.IZ.LT.N) DX1=AN/FLOAT(INTIO)
DF(1)=DX1
30 X1(IZ)=F(1)
XO(IZ)=F(2)
YO(IZ)=F(3)
IF (NDEBUG.EQ.0) PRINT 73, IZ,X1(IZ),XO(IZ),YO(IZ)
IF (NCHANGE.EQ.1.AND.F(1)+DF(1).GT.XIBSBAR) DX1=XIBSBAR-F(1)
IF (NCHANGE.EQ.1.AND.F(1)+DF(1).LT.XIBSBAR.AND.ABS(XIBSBAR-F(1))-DF
1(1)).LT.1.E-07) DX1=XIBSBAR-F(1)
DF(1)=DX1
IF (NDEBUG.EQ.0) PRINT 78, DX1
31 CONTINUE
GO TO 34
B2010
B2020
B2021
B2030
B2040
B2050
B2060
B2070
B2080
B2090
B2100
B2110
B2120
B2130
B2140
B2150
B2160
B2170
B2180
B2190
B2200
B2210
B2220
B2230
B2240
B2250
B2260
B2270
B2280
B2290
B2300
B2310
B2320
B2330
B2340
B2350
B2360
B2370
B2380
B2390
B2400
B2410
B2420
B2430
B2440
B2450
B2460
B2470
B2480
B2490
B2500
B2510
B2520
B2530
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B2660
B2670
B2680
B2690
B2700
B2710
B2720
B2730
B2740
B2750
B2760
B2770
B2780
B2790
B2800
B2810
B2820
B2830
B2840
B2850
B2860
B2870

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APPENDIX B

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32 GO 33 I=1,LMIT
33 X(I)=TAN(X(I))
C
C      GEOMETRIC PARAMETERS FOR CIRCULAR AND ELLIPTIC CONE
C
34 IF (NDEBUG.EQ.1) GO TO 36
DO 35 I=1,LMIT
35 PRINT 69, I,X(I),XO(I),YO(I)
36 IF (N.EQ.3) GO TO 64
DO 44 I=1,LMIT
IF (N.EQ.4) GO TO 37
IF (N.EQ.1.OR.N.EQ.2) GO TO 38
IF (N.EQ.5) GO TO 40
37 GX(I)=2.*XO(I)
GX(I)=2.
GY(I)=2.*(YO(I)-ACC)
GO TO 39
38 GX(I)=2.*XO(I)
GX(I)=2.*XO(I)
GY(I)=2.*YO(I)
GY(I)=2.
39 GY(I)=2.
GX(I)=0.0
GO TO 43
40 IF (XO(I).LT.BSBAR) GO TO 41
IF (XO(I).GE.BSBAR) GO TO 42
41 GX(I)=2.*XO(I)
GY(I)=-2.*SORT(RS**2-XO(I)**2)
GX(I)=2.
GY(I)=2.
GO TO 43
42 GX(I)=TAN(PHIWR)
GY(I)=-1.0
GX(I)=0.0
GY(I)=0.0
43 IF (NDEBUG.EQ.0) PRINT 74, I,GX(I),GY(I),GX(I),GY(I),GX(I)
44 CONTINUE
GO TO 64
C
C      CALCULATION OF BODY GEOMETRY FOR WINDWARD SIDE OF PLATE WITH
C      ROUNDED EDGES - M=6
C
45 NSTEP=2
NINT=5
NQUAD=1
F(1)=0.0
F(2)=0.0
DS=F(1)*AB
DF(1)=DS
NCHANGE=1
CHECK1=XP
CHECK2=XP*F(AB/SORT(2.))
DO 51 I=1,NINT
CALL DERIV (ACC,RC,THETAR,NINT,NCHANGE,NDEBUG,T,AB,F,DF,NF,XOO,XIN
11,XIN,XP,RS,PHIWR,XISBAR,YWIG,BSBAR)
IF (NCHANGE.EQ.3.AND.ABS(F(1))-LE.1.E-10) GO TO 52
CALL RUNKUT (ACC,RC,THETAR,NINT,NCHANGE,NSTEP,NDEBUG,T,AB,F,DF,FC,
1DFC,DS,AB1,AB2,AB3,AB4,NF,EPISGOM,NQUAD,XOO,XIN,XIN,XP,RS,PHIWR,X
2ISBAR,YWIG,BSBAR)
IF (NCHANGE.EQ.1.AND.ABS(CHECK1-F(1))-LE.1.E-07) GO TO 46
IF (NCHANGE.EQ.2.AND.ABS(CHECK2-F(1))-LE.1.E-07) GO TO 47
IF (NCHANGE.EQ.1.AND.(F(1)+DF(1))-LE.CHECK1.AND.CHECK1-(F(1)+DF(1))
1).GT.1.E-07) GO TO 51
IF (NCHANGE.EQ.2.AND.(F(1)+DF(1))-LE.CHECK2.AND.CHECK2-(F(1)+DF(1))
1).GT.1.E-07) GO TO 51
IF (NCHANGE.EQ.1.AND.(F(1)+DF(1))-LE.CHECK1.AND.CHECK1-(F(1)+DF(1))
1).LE.1.E-07) GO TO 48
IF (NCHANGE.EQ.2.AND.(F(1)+DF(1))-LE.CHECK2.AND.CHECK2-(F(1)+DF(1))
1).LE.1.E-07) GO TO 49
IF (NCHANGE.EQ.1.AND.(F(1)+DF(1))-GT.CHECK1) GO TO 48
IF (NCHANGE.EQ.2.AND.(F(1)+DF(1))-GT.CHECK2) GO TO 49
IF (NCHANGE.EQ.3.AND.(F(1)+DF(1))-LE.0.0.AND.ABS(F(1)+DF(1))-GT.1.
1E-07) GO TO 51
IF (NCHANGE.EQ.3.AND.(F(1)+DF(1))-LE.0.0.AND.ABS(F(1)+DF(1))-LE.1.
1E-07) GO TO 50
IF (NCHANGE.EQ.3.AND.(F(1)+DF(1))-GT.0.0) GO TO 50
46 NCHANGE=2
DS=DSHOLD
DF(1)=DS
XIP=F(2)
GO TO 51
47 NCHANGE=3
F(1)=T*AB/SORT(2.)
DS=DSHOLD
DF(1)=DS
GO TO 51
48 DSHOLD=DS
DS=CHECK1-F(1)
DF(1)=DS
82880
82890
82900
82910
82920
82930
82940
82950
82960
82970
82980
82990
83000
83010
83020
83030
83040
83050
83060
83070
83080
83090
83100
83110
83120
83130
83140
83150
83160
83170
83180
83190
83200
83210
83220
83230
83240
83250
83260
83270
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83390
83400
83410
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83490
83500
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83580
83590
83600
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83780
83790
83800
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83870
83880
83890
83900
83910
83920
83930
83940
83950
83960
83970
83980
83990
84000
84010
84020
84030
84040
84050
84060
84070
84080
84090
84100
84110
84120
84130
84140
84150
84160
84170
84180
84190
84200
84210
84220
84230
84240
84250
84260
84270
84280
84290
84300
84310
84320
84330
84340
84350
84360
84370
84380
84390
84400
84410
84420
84430
84440
84450
84460
84470
84480
84490
84500
84510
84520
84530
84540
84550
84560
84570
84580
84590
84600
84610
84620
84630
84640
84650
84660
84670
84680
84690
84700
84710
84720
84730
84740
84750
84760
84770
84780
84790
84800
84810
84820
84830
84840
84850
84860
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APPENDIX B

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DO 53 I=1,N
IF (I.GE.NB) GO TO 62
GX(I)=XO
GY(I)=YD
GZ(I)=ZO
GO TO 63
62 GX(I)=2.*XO(I)-XP
   GY(I)=2.*YO(I)
   GZ(I)=2.*ZO(I)
63 CONTINUE
64 IF (M.EQ.O) LIMITI=1
   IF (M.EQ.1.OR.M.EQ.2.OR.M.EQ.6) LIMITI=N
   IF (M.EQ.3.OR.M.EQ.4.OR.M.EQ.5) LIMITI=N+1

GEOMETRIC PARAMETERS

DO 56 I=1,LIMITI
A1(I)=1.+XO(I)**2+YO(I)**2
A4(I)=XO(I)*GX(I)+YO(I)*GY(I)
A2(I)=GX(I)**2+GY(I)**2+A4(I)**2
A5(I)=GY(I)*YO(I)+A4(I)
A6(I)=GX(I)*XO(I)+A4(I)
A7(I)=XO(I)*GY(I)-YO(I)*GX(I)

THE TERM -2 GX GY HAS BEEN OMITTED IN THE EQUATIONS FOR AB
SINCE GXY IS ZERO FOR ALL BODIES TO BE CONSIDERED FOR THIS
PROGRAM

AB(1)=GY(I)**2+GX(I)*GX(I)+A2(I)**2+GY(I)
IF (M.EQ.6.AND.I.LT.NB) AKB(1)=O.O
IF (M.EQ.6.AND.I.GE.NB) AKB(1)=AB(1)/A2(I)**1.5
IF (M.EQ.6) AKB(1)=AB(1)/A2(I)**1.5
IF (.AND.XO(I).LE.-1.E-10.AND.ABS(YO(I)).LE.1.E-10) GO TO 65
PSID(1)=57.29577951*ATAN2(YO(I),XO(I))
65 Q(1)=1.O
OP(1)=O.O
IF (NDEBUG.EQ.O) PRINT 70
IF (NDEBUG.EQ.O) PRINT 71, A1(I),A2(I),A3(I),A4(I),A5(I),A6(I),A7(
1),AB(1),AKB(1),GX(I),GY(I),PSID(1)
66 CONTINUE
RETURN

C 190 C 200 C 210 C 220 C 230 C 240 C 250 C 260 C 270 C 280 C 290 C 300 C 310 C 320 C 330 C 340 C 350 C 360 C 370 C 380 C 390 C 400 C 410 C 420 C 430 C 440 C 450 C 460 C 470 C 480 C 490 C 500 C 510 C 520 C 530 C 540 C 550 C 560 C 570 C 580 C 590 C 600 C 610 C 620 C 630 C 640 C 650 C 660 C 670 C 680 C 690 C 700 C 710 C 720 C 730 C 740 C 750 C 760 C 770 C 780 C 790 C 800 C 810 C 820 C 830 C 840 C 850 C 860 C 870 C 880 C 890 C 900 C 910 C 920 C 930 C 940 C 950 C 960 C 970 C 980 C 990 C 1000 C 1010 C 1020 C 1030 C 1040 C 1050 C 1060 C 1070 C 1080 C 1090 C 1100 C 1110 C 1120 C 1130 C 1140 C 1150 C 1160 C 1170 C 1180 C 1190 C 1200 C 1210 C 1220 C 1230 C 1240 C 1250 C 1260 C 1270 C 1280 C 1290 C 1300 C 1310 C 1320 C 1330 C 1340 C 1350 C 1360 C 1370 C 1380 C 1390 C 1400 C 1410 C 1420 C 1430 C 1440 C 1450 C 1460 C 1470 C 1480 C 1490 C 1500 C 1510 C 1520 C 1530 C 1540 C 1550 C 1560 C 1570 C 1580 C 1590 C 1600 C 1610 C 1620 C 1630 C 1640 C 1650 C 1660 C 1670 C 1680 C 1690 C 1700 C 1710 C 1720 C 1730 C 1740 C 1750 C 1760 C 1770 C 1780 C 1790 C 1800 C 1810 C 1820 C 1830 C 1840 C 1850 C 1860 C 1870 C 1880 C 1890 C 1900 C 1910 C 1920 C 1930 C 1940 C 1950 C 1960 C 1970 C 1980 C 1990 C 2000 C 2010 C 2020 C 2030 C 2040 C 2050 C 2060 C 2070 C 2080 C 2090 C 2100 C 2110 C 2120 C 2130 C 2140 C 2150 C 2160 C 2170 C 2180 C 2190 C 2200 C 2210 C 2220 C 2230 C 2240 C 2250 C 2260 C 2270 C 2280 C 2290 C 2300 C 2310 C 2320 C 2330 C 2340 C 2350 C 2360 C 2370 C 2380 C 2390 C 2400 C 2410 C 2420 C 2430 C 2440 C 2450 C 2460 C 2470 C 2480 C 2490 C 2500 C 2510 C 2520 C 2530 C 2540 C 2550 C 2560 C 2570 C 2580 C 2590 C 2600 C 2610 C 2620 C 2630 C 2640 C 2650 C 2660 C 2670 C 2680 C 2690 C 2700 C 2710 C 2720 C 2730 C 2740 C 2750 C 2760 C 2770 C 2780 C 2790 C 2800 C 2810 C 2820 C 2830 C 2840 C 2850 C 2860 C 2870 C 2880 C 2890 C 2900 C 2910 C 2920 C 2930 C 2940 C 2950 C 2960 C 2970 C 2980 C 2990 C 3000 C 3010 C 3020 C 3030 C 3040 C 3050 C 3060 C 3070 C 3080 C 3090 C 3100 C 3110 C 3120 C 3130 C 3140 C 3150 C 3160 C 3170 C 3180 C 3190 C 3200 C 3210 C 3220 C 3230 C 3240 C 3250 C 3260 C 3270 C 3280 C 3290 C 3300 C 3310 C 3320 C 3330 C 3340 C 3350 C 3360 C 3370 C 3380 C 3390 C 3400 C 3410 C 3420 C 3430 C 3440 C 3450 C 3460 C 3470 C 3480 C 3490 C 3500 C 3510 C 3520 C 3530 C 3540 C 3550 C 3560 C 3570 C 3580 C 3590 C 3600 C 3610 C 3620 C 3630 C 3640 C 3650 C 3660 C 3670 C 3680 C 3690 C 3700 C 3710 C 3720 C 3730 C 3740 C 3750 C 3760 C 3770 C 3780 C 3790 C 3800 C 3810 C 3820 C 3830 C 3840 C 3850 C 3860 C 3870 C 3880 C 3890 C 3900 C 3910 C 3920 C 3930 C 3940 C 3950 C 3960 C 3970 C 3980 C 3990 C 4000 C 4010 C 4020 C 4030 C 4040 C 4050 C 4060 C 4070 C 4080 C 4090 C 4100 C 4110 C 4120 C 4130 C 4140 C 4150 C 4160 C 4170 C 4180 C 4190 C 4200 C 4210 C 4220 C 4230 C 4240 C 4250 C 4260 C 4270 C 4280 C 4290 C 4300 C 4310 C 4320 C 4330 C 4340 C 4350 C 4360 C 4370 C 4380 C 4390 C 4400 C 4410 C 4420 C 4430 C 4440 C 4450 C 4460 C 4470 C 4480 C 4490 C 4500 C 4510 C 4520 C 4530 C 4540 C 4550 C 4560 C 4570 C 4580 C 4590 C 4600 C 4610 C 4620 C 4630 C 4640 C 4650 C 4660 C 4670 C 4680 C 4690 C 4700 C 4710 C 4720 C 4730 C 4740 C 4750 C 4760 C 4770 C 4780 C 4790 C 4800 C 4810 C 4820 C 4830 C 4840 C 4850 C 4860 C 4870 C 4880 C 4890 C 4900 C 4910 C 4920 C 4930 C 4940 C 4950 C 4960 C 4970 C 4980 C 4990 C 5000 C 5010 C 5020 C 5030 C 5040 C 5050 C 5060 C 5070 C 5080 C 5090 C 5100 C 5110 C 5120 C 5130 C 5140 C 5150 C 5160 C 5170 C 5180 C 5190 C 5200 C 5210 C 5220 C 5230 C 5240 C 5250 C 5260 C 5270 C 5280 C 5290 C 5300 C 5310 C 5320 C 5330 C 5340 C 5350 C 5360 C 5370 C 5380 C 5390 C 5400 C 5410 C 5420 C 5430 C 5440 C 5450 C 5460 C 5470 C 5480 C 5490 C 5500 C 5510 C 5520 C 5530 C 5540 C 5550 C 5560 C 5570 C 5580 C 5590 C 5600 C 5610 C 5620 C 5630 C 5640 C 5650 C 5660 C 5670 C 5680 C 5690 C 5700 C 5710 C 5720 C 5730 C 5740 C 5750 C 5760 C 5770 C 5780 C 5790 C 5800 C 5810 C 5820 C 5830 C 5840 C 5850 C 5860 C 5870 C 5880 C 5890 C 5900 C 5910 C 5920 C 5930 C 5940 C 5950 C 5960 C 5970 C 5980 C 5990 C 6000 C 6010 C 6020 C 6030 C 6040 C 6050 C 6060 C 6070 C 6080 C 6090 C 6100 C 6110 C 6120 C
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APPENDIX B

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IF (NCHANGE.EQ.1) DF(2)=-SORT(A21)/(A1*GY1)
IF (NCHANGE.EQ.2) DF(2)=SORT(A21)/(A1*GX1)
IF (NDEBUG.EQ.0) PRINT 26, NINT,T,AB,F(1),F(2),FB1,GX1,GY1,A11,A41
1,AZ1,F(1),DF(1),DF(2)
RETURN
5 QUAN=AB**2-F(2)**2
FB1=F(SORT(ABS(QUAN)))
GX1=2.*F(2)*F(2)
GY1=2.*F(3)
A11=F(2)*F(2)+F(1)**2
A41=2.*AB**2*F(2)**2
A21=GX1**2+GY1**2+A41**2
DF(2)=A11*GX1/SORT(A21)
DF(3)=A11*GY1/SORT(A21)
IF (NDEBUG.EQ.0) PRINT 26, NINT,T,AB,FB1,GX1,GY1,A11,A21,A41,F(1),
F(2),F(3),DF(1),DF(2),DF(3)
RETURN
6 QUAN=ABS(SORT(RC**2-F(1)**2))
YOO=ACC-QUAN
GX1=2.*F(1)
GY1=2.*QUAN
A11=F(1)**2+YOO**2
A21=GX1**2+GY1**2+F(1)*GX1+YOO*GY1**2
DF(2)=-SORT(A21)/(A1*GY1)
RETURN
7 IF (NCHANGE.EQ.1) GO TO 8
IF (NCHANGE.EQ.2) GO TO 10
8 YOO=T*AB
GX1=0.0
GY1=-1.0
9 A11=F(1)**2+YOO**2
A41=F(1)*GX1+YOO*GY1
A21=GX1**2+GY1**2+A41**2
GO TO 13
10 IF (NCHANGE.EQ.2) GO TO 11
IF (NCHANGE.EQ.3) GO TO 12
11 YOO=-SORT(F(2)*AB**2-F(1)*XP**2)
GX1=2.*F(1)*XP
GY1=2.*YOO
GO TO 9
12 XOO=Y*AB**2-F(2)*AB**2-F(1)*XP**2
GX1=2.*XOO*XP
GY1=2.*F(1)
A11=F(1)+XOO**2+F(1)**2
D 320 25 GX1=TAN(PHIWR)
D 330 GY1=-1.0
D 340 GO TO 18
D 350 C
D 360 C
D 370 26 FORMAT (17H SUBROUTINE DERIV/115/(BE16,B1)
D 380 27 FORMAT (17H SUBROUTINE DERIV/215/(BE16,B1)
D 390 END
D 400 SUBROUTINE APPROX
E 10
D 410 C
E 20
D 420 C
E 30
D 430 C
E 40
D 440 COMMON F(3),DF(3),FC(3),DFC(3),AB1(3),AB2(3),AB3(3),AB4(3)
E 50
D 450 COMMON FUN(20,6),DFUN(20,6),FUNC(20,6),DFUNC(20,6),B1(20,6),B2(20,
E 60
D 460 16),B3(20,6),B4(20,6),SBAR(20),DSBDZ(20),SBARP(20),DSB(20),DSB2(20)
E 70
D 470 2),DSB3(20),DSB4(20),X1(20),X0(20),Y0(20),A1(20),A2(20),A3(20),A4(20)
E 80
D 480 30),A5(20),A6(20),A7(20),A8(20),A9(20),A10(20),GX(20),GY(20),GX1(20),GY1(20)
E 90
D 490 40),GX(20),GY(20),ETA(20),ETAS(20),ETASP(20),GETAD(20),RHO(20),R(20),P(20)
E 100
D 500 5),U(20),V(20),W(20),PP(20),UP(20),VP(20),WP(20),XS(20),YS(20),DUDZ(20)
E 110
D 510 6(20),DPOZ(20),DVOZ(20),DWDZ(20),AM(20),S(20),ZETA(20),ZETA2(20),Z
E 120
D 520 7ETAS(20),ZETA4(20),DUI(20),DUZ(20),DUS(20),DU4(20),DWI(20),DWZ(20)
E 130
D 530 8),DW3(20),DW4(20),DWI(20),DWZ(20),DVA(20),G(20),PSID(20),OP
E 140
D 540 91(20),DPE2(20),DP3(20),DP4(20),OEONS(20),CROSSM(20),RHOISEN(20)
E 150
D 550 COMMON USEN(20),POROGAM(20),G(20),OP(20),PSID(20),BERNOUL(20),XS
E 160
D 560 1BAR(20),YSBAR(20),XOBAR(20),YOBAR(20),XBAR(20),YBAR(20)
E 170
D 570 COMMON AAST,B1,B12,B13,B21,B22,B23,NSPACE,P1,M,N,L1,T,THETAR,GAMM
E 180
D 580 1A,XI1,CON1,CON2,STMACH,AB,A11,A12,A13,A21,A22,A23,A31,A32,A33,ALPH
E 190
D 590 2AR,NH,NDEBUG,H,NK,SIGMA,RAD,NF,NLINES,EPSIG,NPRINT,SPACER,U,LEE,UW1
E 200
D 600 3ND,RHOLEE,RHOWIND,NEXTRAP,EPSIGOM,EPSINT,XIN1,SIGNP1
E 210
D 610 COMMON XP,X1P,PHIWR,GBAR,B5,RS,X1BSBAR
E 220
D 620 COMMON /ERROR/ ER(12),ERR(12),BLK(12)
E 230
D 630 COMMON VCC(20),WCC(20),SBARHLD(20),XBHLD(20),YBHLD(20)
E 240
D 640 COMMON CP(20),XMACHB(20),YMACHB(20),UC(20),VC(20),WC(20),VX(20),VY
E 250
D 650 1(20),THETNOR(20),PSINOR(20),POPT1(20),PTOPT2(20),PT(20),POASTSD(20)
E 260
D 660 2),POPIFN(20),XMACH(20),YMACH(20),CPSHOCK(20),CPBODY(20)
E 270
D 670 COMMON /BLOCK8/ NCNT
E 280
D 680 1
E 290
D 690 IF (NDEBUG.EQ.0) PRINT 12
E 300
D 700 IF (M.EQ.0,OR,M.EQ.2) GO TO 1
E 310
D 710 IF (M.EQ.3,OR,M.EQ.4,OR,M.EQ.5) GO TO 5
E 320
D 720 IF (M.EQ.1,OR,M.EQ.6) GO TO 7
E 330
D 730 C
E 340
D 740 C
E 350
D 750 C
E 360 APPROXIMATE SHOCK SHAPE FOR CIRCULAR AND ELLIPTIC CONES
E 370
E 380
E 390
E 400
E 410
E 420
E 430
E 440
E 450
E 460
E 470
E 480
E 490
E 500
E 510
E 520
E 530
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E 690
E 700
E 710
E 720
E 730
E 740
E 750
E 760
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E 780
E 790
E 800

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APPENDIX B

```

C
7 THETA1=ATAN(T*AB)+ALDVAR
  THETA2=ATAN(T*AB)+ALDVAR
  SNSOBT1=(GAMMA+1.)/2.*SIN(THETA1)**2+1./STNACH**2
  SNSOBT2=(GAMMA+1.)/2.*SIN(THETA2)**2+1./STNACH**2
  BETA1=ASIN(SORT(SNSOBT1))
  BETA2=ASIN(SORT(SNSOBT2))
  ETAS1=BETA1-THETA1
  ETAS2=BETA2-THETA2
  SNSOBN1=(GAMMA+1.)/2.*SIN(THETA1)**2+1./STNACH**2
  BETA1=ASIN(SORT(SNSOBN1))
  ETASN1=BETA1-THETA1
  IF (NDEBUG.EQ.0) PRINT 16, BLK(1),THETA1,THETA2,SNSOBT1,SNSOBT2,BE
17A1,THETA2,ETAS1,ETAS2,SNSOBN1,BETA1,ETASN1
  DO 10 I=1,N
    IF (X(I)-XINI) 8,8,9
8 ETAS11=ETAS1+ETASN1-ETAS1*(X(I)/XINI)**2
  GO TO 10
9 ETAS11=ETAS2+ETASN1-ETAS2*(X(I)-XINI)/XINI)**2
10 CONTINUE
11 IF (NDEBUG.EQ.0) PRINT 14, (X(I),ETAS11),I,N
  RETURN
C
12 FORMAT (18H SUBROUTINE APPROX)
13 FORMAT (18H THETA1=E16.8,2X,BHETAN1=E16.8,2X,7HBETAD1=E16.8,2X,7H
14BETAD2=E16.8)
14 FORMAT (3H 1=14,2X,6HX(1)=E16.8,2X,BHETAS(1)=E16.8)
15 FORMAT (8H THETA1=E16.8,2X,7HBETAND1=E16.8)
16 FORMAT (X1A6/(BET16.8))
  END
  SUBROUTINE LGRANGE (M,I,NP,NLINES,NLINEP,NDEBUG,XO,XREAL,YREAL,X,
  Y,DYDX)
C
C ESTABLISHES LINE ARRANGEMENT, ACCOUNTING FOR SYMMETRY WHERE
C APPROPRIATE, FOR COMPUTATION OF XI DERIVATIVES FOR FUNCTION
C DIFF
C
  DIMENSION XREAL(NLINEP), YREAL(NLINEP), X(NP), Y(NP)
  COMMON /BLOCK1/ ISTL,NCYCLE,NCOUNT
  NDEB=1
  IF (NDEBUG.EQ.0) PRINT 13
  IF (NDEBUG.EQ.0) PRINT 14, I,NP,NLINES,XO
  IF (NDEBUG.EQ.0) PRINT 15, (XREAL(1),YREAL(1)),I,NLINES)
  NE=(NP-1)/2
  N=NE+1
  X(N)=XREAL(1)
  Y(N)=YREAL(1)
  IF (M.EQ.0.OR.M.EQ.2) GO TO 1
  IF (M.EQ.4.OR.M.EQ.6) GO TO 3
  NTEST=NLINES+1-(NP-1)/2
  IF (1-NTEST) 1,4,4
  1 IZZ=0
  DO 2 I=1,NE
    IF ((I+1).GT.NLINES) IZZ=IZZ+1
    IF ((I+1).GT.NLINES) IX1=NLINES-IZZ
    IF ((I+1).LE.NLINES) IX1=ABS(I+1)
    IF ((I-1).LE.0) IX2=ABS(I-1)+1
    IF ((I-1).GT.0) IX2=ABS(I-1)
    IF ((I+1).LE.NLINES) X(N+1)=XREAL(IX1)
    IF ((I+1).GT.NLINES) X(N+1)=2.*XREAL(NLINES)-XREAL(IX1)
    X(N-1)=XREAL(IX2)
    IF ((I-1).LE.0) X(N-1)=XREAL(IX2)
    IF ((I+1).GT.NLINES.AND.ISTL.EQ.5) Y(N+1)=YREAL(IX1)
    IF ((I+1).GT.NLINES.AND.ISTL.NE.5).OR.((I-1).LE.NLINES) Y(N+1)
1=YREAL(IX1)
    IF ((I-1).LE.0.AND.ISTL.EQ.5) Y(N-1)=YREAL(IX2)
    IF ((I-1).LE.0.AND.ISTL.NE.5).OR.((I-1).GT.0) Y(N-1)=YREAL(IX
12)
2 CONTINUE
  NP1=NP
  GO TO 8
3 NTEST15=NLINES-(NP-1)/2
  IF (1-NTEST15) 1,1,5
4 NTEST1=NLINES+1-1
  NTEST2=(NP-1)/2
  IF (NTEST1.EQ.NTEST2) NP1=NP
  IF (NTEST1.LT.NTEST2) NP1=2*(NLINES+1-1)+1
  JB=NLINES-NP1+2
  NE=(NP1-1)/2
  N=NE+1
  LL=NLINEP1
  GO TO 6
5 IF (1.EQ.NLINES) GO TO 9
  NP1=2*(NLINES-1)+1
  JB=NLINES-NP1+1
  NE=(NP1-1)/2
  N=NE+1
  LL=NLINES
  E 810 LL=NLINES
  E 820 NN=0
  E 830 DO 7 J=JB,LL
  E 840 NN=NN+1
  E 850 X(NN)=XREAL(J)
  E 860 Y(NN)=YREAL(J)
  E 870 7 IF (NDEBUG.EQ.0) PRINT 11, (X(1),Y(1),I,NP1)
  E 880 IF (NDEBUG.EQ.0) PRINT 16, N,NE,NP1
  E 890 DYDX=DIFF(N,NE,NP1,X,Y)
  E 900 GO TO 10
  E 910 9 DYDX=(YREAL(NLINES)-YREAL(NLINES-1))/(XREAL(NLINES)-XREAL(NLINES-1))
  E 920 11)
  E 930 10 IF (NDEBUG.EQ.0) PRINT 12, DYDX
  E 940 RETURN
  E 950 C
  E 960 C
  E 970 11 FORMAT (4H 11=14,2X,6HX(1)=E16.8,2X,6HY(1)=E16.8)
  E 980 12 FORMAT (6H DYDX=E16.8)
  E 990 13 FORMAT (19H SUBROUTINE LGRANGE)
  E1000 14 FORMAT (3H 1=14,2X,3HNP=14,2X,7HNLINES=14,2X,3HXO=E16.8)
  E1010 15 FORMAT (4H 11=14,2X,10HXREAL(1)=E16.8,2X,10HYREAL(1)=E16.8)
  E1020 16 FORMAT (3H N=12,2X,3HNE=12,2X,4HNP=12/)
  E1030 END
  E1040 SUBROUTINE DIRCOS (I)
  E1050 C
  E1060 C
  E1070 C COMPUTE DIRECTION COSINES OF R,ETA,TAU COORDINATES
  E1080 C
  E1090 COMMON F(3),DF(3),FC(3),DFC(3),AB(3),AB2(3),AB3(3),AB4(3)
  E1100 COMMON FUN(20,6),DFUN(20,6),FUNC(20,6),DFUNC(20,6),B1(20,6),B2(20,
  E1110 6),B3(20,6),B4(20,6),SBAR(20),DSBZ(20),SBAR(20),DSB1(20),DSB2(20,
  E1120 2),DSB3(20),DSB4(20),X(20),X0(20),Y(20),A1(20),A2(20),A3(20),A4(2
  E1130 0),GXY(20),ETA(20),ETAS(20),ETASP(20),BETA(20),RHO(20),R(20),P(20
  E1140 5),U(20),V(20),W(20),UP(20),VP(20),WP(20),XS(20),YS(20),DZ(20)
  E1150 6),DPDZ(20),DWDZ(20),DWDZ(20),AM(20),S(20),ZETA1(20),ZETA2(20),Z
  E1160 7),ZETA3(20),ZETA4(20),DU1(20),DU2(20),DU3(20),DU4(20),DW1(20),DW2(20)
  E1170 8),DW3(20),DW4(20),DV1(20),DV2(20),DV3(20),DV4(20),PSID(20),DP
  E1180 9),DP2(20),DP3(20),DP4(20),DECN5(20),CROSSM(20),RHOISEN(20)
  E1190 COMMON UISEN(20),POROGAM(20),Q(20),OP(20),PSID(20),BERNOLA(20),XS
  E1200 1BAR(20),YSBAR(20),X0BAR(20),Y0BAR(20),XBAR(20),YBAR(20)
  E1210 COMMON AAS1,B11,B12,B13,B21,B22,B23,NSPACE,PI,N,NL1,T,THETA1,GAMM
  E1220 1A(20),CON1,CON2,STACH,AB,A11,A12,A13,A21,A22,A23,A31,A32,A33,ALPH
  E1230 2AR,N,N,NDEBUG,H,HK,SIGMA,RAD,NF,NLINES,EPSIG,NPRINT,SPACER,ULEE,UW1
  E1240 3ND,RHOLEE,RHOWIND,NEXTAP,EPSIGOM,EPSINT,XINI,SIGNP1
  E1250 G 220 COMMON XP,XIP,PHI,WP,BSBAR,DS,RS,XIBSBAR
  E1260 COMMON /ERROR/ ER(12),ERR(12),BLK(12)
  E1270 COMMON VCC(20),WCC(20),SBARHLD(20),XBHLD(20),YBHLD(20)
  E1280 COMMON CP(20),XMACB(20),YMACB(20),UC(20),VC(20),WC(20),VX(20),VY
  E1290 1(20),THETNOR(20),PSINOR(20),POPT1(20),POPT2(20),PT(20),POASTPS(20)
  E1300 2),POPTINF(20),XMACH(20),YMACH(20),CPSHOCK(20),CPDOPY(20)
  E1310 IF (NDEBUG.EQ.0) PRINT 2
  E1320 IF (NDEBUG.EQ.0) PRINT 1, 1,ETA(1),A1(1),A2(1),A3(1),A4(1),A5(1),A
  E1330 16(1),A7(1),AB(1),GX(1),GY(1),X0(1),Y0(1)
  E1340 QUAN1=CON1/SORT(A1(1))
  E1350 QUAN2=CON2/SORT(A2(1))
  E1360 QUAN3=CON2/SORT(A1(1))
  E1370 QUAN4=CON1/SORT(A2(1))
  E1380 QUAN5=1./SORT(A1(1)*A2(1))
  E1390 A11=XO(1)*QUAN1+GX(1)*QUAN2
  E1400 A12=XO(1)*QUAN1+GY(1)*QUAN2
  E1410 A13=XO(1)*QUAN1+A4(1)*QUAN2
  E1420 A21=XO(1)*QUAN1+GY(1)*QUAN2
  E1430 A22=XO(1)*QUAN1+XO(1)*QUAN2
  E1440 A23=XO(1)*QUAN1+A7(1)
  E1450 A31=XO(1)*QUAN3+GX(1)*QUAN4
  E1460 A32=XO(1)*QUAN3+GY(1)*QUAN4
  E1470 A33=XO(1)*QUAN3+A4(1)*QUAN4
  E1480 IF (NDEBUG.EQ.0) PRINT 1, 1,QUAN1,QUAN2,QUAN3,QUAN4,QUAN5,A11,A12,
  E1490 1A13,A21,A22,A23,A31,A32,A33
  E1500 PHIR=ATAN2(GY(1),GX(1))
  E1510 SINPHIR=SIN(PHIR)
  E1520 COSPHIR=COS(PHIR)
  E1530 B11=A11*COSPHIR+A12*SINPHIR
  E1540 B12=A21*COSPHIR+A22*SINPHIR
  E1550 B13=A31*COSPHIR+A32*SINPHIR
  E1560 B21=A11*SINPHIR+A12*COSPHIR
  E1570 B22=A21*SINPHIR+A22*COSPHIR
  E1580 B23=A31*SINPHIR+A32*COSPHIR
  E1590 IF (NDEBUG.EQ.0) PRINT 1, 1,GY(1),GX(1),PHIR,SINPHIR,COSPHIR,B11,B
  E1600 112,B13,B21,B22,B23
  E1610 RETURN
  E1620 C
  E1630 1 FORMAT (3H 1=15/(BET16.8))
  E1640 2 FORMAT (18H SUBROUTINE DIRCOS/)
  E1650 END
  E1660 SUBROUTINE SHOCK (I)
  E1670 C
  E1680 C
  E1690 C
  E1700 C
  E1710 C
  E1720 C
  E1730 C
  E1740 C
  E1750 C
  E1760 C
  E1770 C
  E1780 C
  E1790 C
  E1800 C
  E1810 C
  E1820 C
  E1830 C
  E1840 C
  E1850 C
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APPENDIX B

[illegible]

APPENDIX B

	2).POPINF(20).XMACH(20).YMACH(20).CPSHOCK(20).CPBODY(20)	J 270		7 IF (NDEBUG.EQ.0) PRINT 13, BLK(6),1,DFUN(1,1),DFUN(1,2),DFUN(1,3),	J1110
	COMMON /BLOCK6/ NEGP	J 280		10FUN(1,4),DFUN(1,5),DFUN(1,6)	J1120
	IF (NDEBUG.EQ.0) PRINT 12	J 290		GO TO 11	J1130
C	GEOMETRIC PARAMETERS	J 300	C	EXTRAPOLATION OF VELOCITIES AND PRESSURE	J1140
C		J 310	C		J1150
C		J 320	C		J1160
	NEXTTRAP=0	J 330		8 NEXTTRAP=1	J1170
	BX=1.	J 331		DO 9 I=1,N	J1180
	IF (M.EQ.5) BX=BSBAR/AB	J 332		FUN(1,1)=FUNG(1,1)	J1190
	DO 11 I=1,N	J 340		FUN(1,2)=FUNG(1,2)	J1200
	ANUM=2*FUNG(1,1)*ETAS(1)	J 350		FUN(1,3)=FUNG(1,3)	J1210
	SORT1=SQRT(1+(1)*2+4*FUNG(1,1)*(-Q(1)))	J 360		FUN(1,4)=FUNG(1,4)	J1220
	IF (Q(1).GE.0.0) ETA(1)=ANUM/(Q(1)+SORT1)	J 370		FUN(1,5)=FUNG(1,5)	J1230
	IF (Q(1).LT.0.0) ETA(1)=ANUM/(Q(1)-SORT1)	J 380		FUN(1,6)=FUNG(1,6)	J1240
	IF (NDEBUG.EQ.0) PRINT 13, BLK(1),1,ETAS(1),ETASP(1),ETAS(1),ANUM,S	J 390		9 CONTINUE	J1250
	10RT1=FUNG(1,1),FUNG(1,2),FUNG(1,3)+FUNG(1,4),FUNG(1,5)+Q(1),DP(1),AKB(1	J 400		GO TO 1	J1260
	2),GAMMA,STMAH,AB,PP(1),VP(1),ZETA(1),ZETA2(1),ZETA3(J 410		10 DENOM1=(ZETA4(1)-ZETA3(1))*ZETA4(1)-ZETA2(1)	J1270
	31),ZETA4(1),DU1(1),DU2(1),DU3(1),DU4(1),DP(1),DP2(1),DP3(1),DPA(1	J 420		DENOM2=(ZETA3(1)-ZETA4(1))*ZETA3(1)-ZETA2(1)	J1280
	41),DV1(1),DV2(1),DV3(1),DV4(1),DW1(1),DW2(1),DW3(1),DW4(1),FUNG(1,6)	J 430		DENOM3=(ZETA2(1)-ZETA4(1))*ZETA2(1)-ZETA3(1)	J1290
	F1B=D(1)*2*Q(1)-Q(1))*ETAS(1)/ETAS(1)	J 440		FF1=FUNG(1,1)**3/3	J1300
	G1B=ETA(1)*DP(1)*(-1,-ETA(1)/ETAS(1))-ETASP(1)*F1B/ETAS(1)	J 450		FF2=FUNG(1,1)**2/2	J1310
	CON1=SIGN(ETA(1))	J 460		TERM31=FUNG(1,1)*ZETA2(1)*ZETA3(1)	J1320
	CON2=COS(ETA(1))	J 470		TERM32=FUNG(1,1)*ZETA4(1)*ZETA2(1)	J1330
	H=CON2-AKB(1)*CON1	J 480		TERM33=FUNG(1,1)*ZETA4(1)*ZETA3(1)	J1340
	HK=CON1-AKB(1)*CON2	J 490		FAC1=(FF1-FF2*(ZETA3(1)+ZETA2(1))+TERM31)/DENOM1	J1350
	IF (M.EQ.5) AND(BX.LT.XOBAR(2)) H=CON2	J 491		FAC2=(FF1-FF2*(ZETA4(1)+ZETA2(1))+TERM32)/DENOM2	J1360
	IF (M.EQ.5) AND(BX.LT.XOBAR(2)) HK=CON1	J 492		FAC3=(FF1-FF2*(ZETA4(1)+ZETA3(1))+TERM33)/DENOM3	J1370
	IF (ABS(H).GE.1.0E-07) GO TO 2	J 500		FUN(1,2)=FUNG(1,2)-FAC1*DU4(1)-FAC2*DU3(1)-FAC3*DU2(1)	J1380
	PRINT 13, ERR(1),1,FUN(1,1),ETAS(1),ETA(1),CON1,CON2,H+HK	J 510		FUN(1,3)=FUNG(1,3)-FAC1*DP4(1)-FAC2*DP3(1)-FAC3*DP2(1)	J1390
	STOP 1201	J 520		FUN(1,4)=FUNG(1,4)-FAC1*DV4(1)-FAC2*DV3(1)-FAC3*DV2(1)	J1400
	2 TANSIG=ETASP(1)/H	J 530		FUN(1,5)=FUNG(1,5)-FAC1*DW4(1)-FAC2*DW3(1)-FAC3*DW2(1)	J1410
	SIGMA=ATAN(TANSIG)	J 540		FUN(1,6)=FUNG(1,6)-FAC1*DPA(1)-FAC2*DPA(1)-FAC3*DPA(1)	J1420
C		J 550		FUN(1,1)=Q	J1430
C	FUNCTIONS AND PARAMETERS	J 560		IF (NDEBUG.EQ.0) PRINT 13, BLK(9),1,FUN(1,2),FUNG(1,3),FUNG(1,4),FUNG	J1440
C		J 570		1(1,5),FUNG(1,6)	J1450
	BUS0=FUNG(1,2)*2*FUNG(1,4)*2*FUNG(1,5)**2	J 580		11 CONTINUE	J1460
	DENOM=EXP(FUNG(1,6))	J 590		RETURN	J1470
	IF (NDEBUG.EQ.0) PRINT 13, BLK(2),1,CON1,CON2,AKB(1),H+HK,ETASP(1)	J 600	C		J1480
	1,TANSIG,SIGMA,BUS0,GAMMA,STMAH,DENOM,F1B,G1B	J 610	C		J1490
	IF (ABS(DENOM).GE.1.0E-07) AND(FUNG(1,3)+GT.0.0) GO TO 3	J 620		12 FORMAT (16H SUBROUTINE EQNS)	J1500
	PRINT 13, ERR(2),1,GAMMA,STMAH,TANSIG,SIGMA,BUS0,DENOM,FUNG(1,1),F	J 630		13 FORMAT (1X16,15/BE16.8)	J1510
	1UN(1,2),FUNG(1,3),FUNG(1,4),FUNG(1,5)	J 640		14 FORMAT (1/25H OUCH - NEGATIVE PRESSURE//)	J1520
	NEGP=0	J 650		END	J1530
	PRINT 14	J 660		SUBROUTINE RUNKUT2 (N,NP)	K 10
	RETURN	J 670	C		K 20
	3 RHO(1)=(GAMMA*STMAH**2*FUNG(1,3)/DENOM)**(1./GAMMA)	J 680	C	INTEGRATION OF EQUATIONS	K 30
	DENOM=1+2*FUNG(1,6)/(GAMMA-1)*STMAH**2	J 690	C		K 40
	BERNOULI(1)=1-12.*GAMMA*FUNG(1,3)/(RHO(1)*(GAMMA-1))+BUS0*AAST**2)	J 700		COMMON F(3),DF(3),FC(3),DFC(3),AB1(3),AB2(3),AB3(3),AB4(3)	K 50
	1/DENOM	J 710		COMMON FUN(20,6),DFUN(20,6),FUNG(20,6),DFUNG(20,6),B1(20,6),B2(20,	K 60
	IF (RHO(1).GE.1.E-10) GO TO 4	J 720		161)+B3(20,6)+B4(20,6),SBAR(20),DSB02(20),SBARP(20),DSB1(20),DSB2(20	K 70
	PRINT 13, ERR(3),1,BUS0,DENOM,RHO(1),FUNG(1,3)	J 730		2),DSB3(20),DSB4(20),X1(20),X0(20),Y0(20),A1(20),A2(20),A3(20),A4(2	K 80
	STOP 1203	J 740		301)+A5(20)+A6(20),A7(20),AB1(20),AKB(20),GX(20),GY(20),GX(20),GY(2	K 90
	4 AS0=GAMMA*FUNG(1,3)/RHO(1)	J 750		401)+GY(20),ETA(20),ETAS(20),ETASP(20),BETAD(20),RHO(20),R1(20),P(20	K 100
	IF (NDEBUG.EQ.0) PRINT 13, BLK(3),1,RHO(1),AS0	J 760		51),U1(20),V1(20),W1(20),VP(20),VP(20),VP(20),X5(20),Y5(20),DUDZ	K 110
	IF (AS0+GT.1.E-20) GO TO 5	J 770		620),DPOZ(20),DVOZ(20),DWDZ(20),AM(20),S(20),ZETA1(20),ZETA2(20),Z	K 120
	PRINT 13, ERR(4),1,FUNG(1,1),FUNG(1,3),RHO(1),BUS0,AS0	J 780		7ETA3(20),ZETA4(20),DU1(20),DU2(20),DU3(20),DU4(20),DW1(20),DW2(20)	K 130
	STOP 1204	J 790		81)+DW3(20),DW4(20),DW1(20),DW2(20),DW3(20),DW4(20),PSID(20),OP	K 140
	5 AM(1)=SQRT(AAST**2*BUS0/AS0)	J 800		91(20),DP2(20),DP3(20),DP4(20),DEONS(20),CROSSM(20),RHOISEN(20)	K 150
	CROSSM(1)=SQRT(AAST**2*(BUS0-FUNG(1,2)*2)/AS0)	J 810		COMMON UISEN(20),POROGAM(20),Q1(20),OP(20),PSISD(20),BERNOULI(20),X5	K 160
	POROGAM(1)=FUNG(1,3)/RHO(1)*GAMMA	J 820		1BAR(20),YSBAR(20),XOBAR(20),YOBAR(20),XBAR(20),YBAR(20)	K 170
	S(1)=ALOG(FUNG(1,3)*GAMMA*STMAH**2/RHO(1)*GAMMA)	J 830		COMMON AAST,B1,B2,B3,B4,B5,B6,B7,B8,B9,B10,B11,B12,B13,B14,B15,B16,B17,B18,B19,B20	K 180
	FF=ETAS(1)*(H*FUNG(1,4)+2*FUNG(1,5)*2)-FUNG(1,5)*VP(1)	J 840		1A,DX1,CON1,CON2,STMAH,AB,A1,A2,A3,A4,A5,A6,A7,A8,A9,A10,A11,A12,A13,A14,A15,A16,A17,A18,A19,A20,ALPH	K 190
	F1=ETAS(1)*FUNG(1,5)*VP(1)/RHO(1)+AS0*VP(1)+2.*H*FUNG(1,2)-HK*FUNG(1	J 850		2AR,N1,NDEBUG,H,HK,SIGMA,RAD,NF,NLINES,EPSIG,NPRINT,SPACER,UJEE,UWJ	K 200
	1,41)	J 860		3ND,RHOLE,RHOW,ND,NEXTTRAP,EPSIGM,EPSINT,XIN1,SIGNP	K 210
	F2=ETAS(1)*FUNG(1,5)*VP(1)+H*FUNG(1,2)*FUNG(1,4)+HK*FUNG(1,5)*2)	J 870		COMMON XP,XIP,PHIWR,BSBAR,BS,RS,X1BSBAR	K 220
	F3=ETAS(1)*BP(1)/RHO(1)+AAST**2*FUNG(1,5)*VP(1)+H*FUNG(1,2)*FUNG(1	J 880		COMMON /ERROR/ ER(12),ERR(12),BLK(12)	K 230
	1,51)-HK*FUNG(1,4)*FUNG(1,51)	J 890		COMMON VCC(20),WCC(20),SBARHLID(20),XBMLD(20),YBMLD(20)	K 240
	G(1)=H*FUNG(1,4)*F1B+FUNG(1,5)*G1B	J 900		COMMON CP(20),XMAHCB(20),YMACHCB(20),UC(20),VC(20),WC(20),VX(20),VY	K 250
	DEONS(1)=(H*F1B/AAST**2+G1B/AAST**2-G(1))*2/AS0	J 910		1(20),THETNOR(20),PSINOR(20),PORT(20),PTOPT(20),PT(20),POASTSQ(20	K 260
	IF (NDEBUG.EQ.0) PRINT 13, BLK(4),1,AM(1),CROSSM(1),POROGAM(1),S(1	J 920		2),POPINF(20).XMAHCB(20).YMACHCB(20).CPSHOCK(20).CPBODY(20)	K 270
	1),UP(1),VP(1),WP(1),SBARP(1),FF,F1,F2,F3,QUAN,F1B,G1B,G(1)+O	J 930		COMMON /BLOCK6/ NEGP	K 280
	2EONS(1)	J 940			K 290
	IF (NEXTTRAP.EQ.1) GO TO 10	J 950		IF (NDEBUG.NE.0) GO TO 2	K 300
	IF ((G(1),GT,EPSIG,OR,DEONS(1),LT,EPSIG),AND,FUNG(1,1),GE,.80) GO T	J 960		PRINT 27	K 310
	10 6	J 970		DO 1 I=1,N	K 320
	IF (ABS(G(1)).LT,EPSIG,OR,G(1),GT,0.,OR,DEONS(1),LT,0.) GO TO 8	J 980		1 PRINT 28, 1,(NXF,FUNG(1,NXF),DFUN(1,NXF),NXF=1,NF)	K 330
C		J 990		2 TESTMAX=5*EPSINT	K 340
C	ZETA DERIVATIVES	J1000		DSMAX=1	K 350
C		J1010		DSMAX=1	K 360
	6 DFUN(1,2)=FF/G(1)	J1020	C		K 370
	DFUN(1,3)=RHO(1)/DEONS(1)*(F1*G(1)-F2*H*F1B-F3*G1B)	J1030		IF (DSMIN.EQ.DSMAX) GIVES A FIXED INTEGRATION STEP	K 380
	DFUN(1,4)=1./G(1)*(H*F1B*DFUN(1,3)/(AAST**2*RHO(1))+F2)	J1040		IF (DSMIN.NE.DSMAX) GIVES A VARIABLE INTEGRATION STEP	K 390
	DFUN(1,5)=1./G(1)*(G1B*DFUN(1,3)/(AAST**2*RHO(1))+F3)	J1050	C		K 400
	DFUN(1,6)=ETAS(1)*FUNG(1,5)*SBARP(1)/G(1)	J1060		IF (DSMIN.NE.DSMAX) GO TO 3	K 410
	IF (FUNG(1,1),GT,.05) GO TO 7	J1070		DS=DSMAX	K 420
	IF (1.EQ.1) GO TO 7	J1080		IF (FUNG(1,1)-1,GT,1.E-07) DS=-1	K 430
	IF (M.EQ.2) AND(1.EQ.N) GO TO 7	J1090		IF (FUNG(1,1)-1,LE,1.E-07) DS=-0.5	K 440
	IF (DFUN(1,6),GT,0.) GO TO 8	J1100		IF (FUNG(1,1)-0.5,LE,1.E-07) DS=-0.25	K 450

APPENDIX B

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3 IF (FUN(1,1)-.025*LE,1,E-07) DS=-.0125
3 IF (FUN(1,1)-.NE,1,0) GO TO 5
DO 4 I=1,N
4 DFUN(I,1)=DS
SET EXTRAPOLATION PARAMETERS
5 DO 6 I=1,N
6 (ZETA4(I)=FUN(I,1)+LT*SPACER.AND.FUN(I,1)+LT,1) GO TO 6
IF (GT,EP SIG,OR,DEGMS(I)+LT,EP SIG) GO TO 6
ZETA1(I)=ZETA2(I)
ZETA2(I)=ZETA3(I)
ZETA3(I)=ZETA4(I)
ZETA4(I)=FUN(I,1)
DU1(I)=DU2(I)
DU2(I)=DU3(I)
DU3(I)=DU4(I)
DU4(I)=DFUN(I,2)
DP1(I)=DP2(I)
DP2(I)=DP3(I)
DP3(I)=DP4(I)
DP4(I)=DFUN(I,3)
DV1(I)=DV2(I)
DV2(I)=DV3(I)
DV3(I)=DV4(I)
DV4(I)=DFUN(I,4)
DW1(I)=DW2(I)
DW2(I)=DW3(I)
DW3(I)=DW4(I)
DW4(I)=DFUN(I,5)
DSB1(I)=DSB2(I)
DSB2(I)=DSB3(I)
DSB3(I)=DSB4(I)
DSB4(I)=DFUN(I,6)
CONTINUE
DO 8 I=1,N
8 DFUNC(I,NXF)=DFUN(I,NXF)
7 FUNC(I,NXF)=FUNC(I,NXF)
CONTINUE
DO 10 I=1,N
10 DFUN(I,1)=DS
IF (NDEBUG.EQ.0) PRINT 29, DS
DO 11 I=1,N
DO 11 NXF=2,NF
B1(I,NXF)=DS*DFUNC(I,NXF)
11 FUNC(I,NXF)=FUNC(I,NXF)+B1(I,NXF)/2.
DO 12 I=1,N
12 FUNC(I,1)=FUNC(I,1)+DS/2.
IF (NDEBUG.NE.0) GO TO 14
DO 13 I=1,N
13 PRINT 30, I,NXF,B1(I,NXF),FUNC(I,NXF),NXF,I,NF
14 CALL DERIV2 (DS,NP)
IF (NEXTRAP.EQ.1) RETURN
IF (NEGP.EQ.0) RETURN
DO 15 I=1,N
15 NXF=2,NF
B2(I,NXF)=DS*DFUN(I,NXF)
15 FUNC(I,NXF)=FUNC(I,NXF)+B2(I,NXF)/2.
IF (NDEBUG.NE.0) GO TO 17
DO 16 I=1,N
16 PRINT 31, I,NXF,B2(I,NXF),FUNC(I,NXF),NXF,I,NF
17 CALL DERIV2 (DS,NP)
IF (NEXTRAP.EQ.1) RETURN
IF (NEGP.EQ.0) RETURN
NCCNT=0
DO 19 I=1,N
FUNC(I,1)=FUNC(I,1)+DS
DO 19 NXF=2,NF
B3(I,NXF)=DS*DFUN(I,NXF)
IF (ABS(B2(I,NXF)/DS)+LE,1,E-03) GO TO 18
TEST=ABS(1-B3(I,NXF)/B2(I,NXF))
NCCNT=NCCNT+1
IF (NCCNT.EQ.1) TESTMAX=TEST
IF (TEST.GT.TESTMAX) TESTMAX=TEST
18 FUNC(I,NXF)=FUNC(I,NXF)+B3(I,NXF)
IF (NDEBUG.EQ.0) PRINT 32, I,NXF,B3(I,NXF),FUNC(I,NXF),TEST
CONTINUE
IF (DSMIN.EQ.DSMAX) GO TO 20
IF (TESTMAX.GE.EPSINT.AND.ABS(DS).GT.DSMIN) GO TO 24
CALL DERIV2 (DS,NP)
IF (NEXTRAP.EQ.1) RETURN
IF (NEGP.EQ.0) RETURN
DO 21 I=1,N
DO 21 NXF=2,NF
B4(I,NXF)=DS*DFUN(I,NXF)
21 FUNC(I,NXF)=FUNC(I,NXF)+1./6.*B1(I,NXF)+2.*B2(I,NXF)+3.*B3(I,NXF)+
184(I,NXF)
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APPENDIX B

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IF (T.GT.1..AND.SBARHLD(I+1).GT.SBARHLD(I)) GO TO 7      L 610
5 IF (SBAR(I).GE.SBARHLD(I).AND.SBAR(I+1).LE.SBARHLD(I)) GO TO 6      L 620
GO TO 7      L 630
6 XBHLD(I)=XBAR(I)+(SBARHLD(I)-SBAR(I))*(XBAR(I+1)-XBAR(I))/(SSA      L 640
IR(I+1)-SBAR(I))      L 650
XBHLD(I)=YBAR(I)+(SBARHLD(I)-SBAR(I))*(YBAR(I+1)-YBAR(I))/(SSA      L 660
IR(I+1)-SBAR(I))      L 670
GO TO 8      L 680
7 CONTINUE      L 690
8 CONTINUE      L 700
GO TO 11      L 710
9 DO 10 I=2,LIMIT      L 720
XBHLD(I)=XBAR(LIMIT)      L 730
10 YBHD(I)=YBAR(LIMIT)      L 740
11 NZETA=NZETA+1      L 750
XBHLD(I)=XBAR(I)      L 760
XBHLD(LIMIT)=XBAR(LIMIT)      L 770
YBHD(I)=YBAR(I)      L 780
YBHD(LIMIT)=YBAR(LIMIT)      L 790
IF (NPLOT.EQ.1) PUNCH 25, (XBHLD(I),I=1,LIMIT)      L 800
IF (NPLOT.EQ.1) PUNCH 25, (YBHD(I),I=1,LIMIT)      L 810
12 PRINT 25, NAME4(1), (P(I),I=1,L,L)      L 820
PRINT 25, NAME4(12), (POASTO(I),I=1,L,L)      L 830
PRINT 25, NAME4(9), (POPT(I),I=1,L,L)      L 840
PRINT 25, NAME4(14), (POPIF(I),I=1,L,L)      L 850
PRINT 25, NAME(2), (RHO(I),I=1,L,L)      L 860
PRINT 25, NAME(4), (U(I),I=1,L,L)      L 870
PRINT 25, NAME(5), (V(I),I=1,L,L)      L 880
PRINT 25, NAME(6), (W(I),I=1,L,L)      L 890
PRINT 25, NAME(14), (UC(I),I=1,L,L)      L 900
PRINT 25, NAME(15), (VC(I),I=1,L,L)      L 910
PRINT 25, NAME(16), (WC(I),I=1,L,L)      L 920
PRINT 25, NAME4(15), (VCC(I),I=1,L,L)      L 930
PRINT 25, NAME4(16), (WCC(I),I=1,L,L)      L 940
PRINT 25, NAME4(4), (VX(I),I=1,L,L)      L 950
PRINT 25, NAME4(5), (VY(I),I=1,L,L)      L 960
PRINT 25, NAME4(16), (UC(I),I=1,L,L)      L 970
PRINT 25, NAME4(7), (PSINOR(I),I=1,L,L)      L 980
PRINT 25, NAME4(8), (THEINOR(I),I=1,L,L)      L 990
PRINT 25, NAME4(2), (XBAR(I),I=1,L,L)      L1000
PRINT 25, NAME4(19), (XBHLD(I),I=1,L,L)      L1010
PRINT 25, NAME4(3), (YBAR(I),I=1,L,L)      L1020
PRINT 25, NAME4(20), (YBHD(I),I=1,L,L)      L1030
PRINT 25, NAME(11), (ETA(I),I=1,L,L)      L1040

GO TO (12,18), LPRINT      L1490
17 LB=LL+1      L1500
LL=LIMIT      L1510
PRINT 28      L1520
GO TO (12,18), LPRINT      L1530
18 PRINT 25, NAME2(1), (PSTD(I),I=1,L,L)      L1540
PRINT 25, NAME4(1), (PSTD(I),I=1,L,L)      L1550
PRINT 25, NAME2(2), (XO(I),I=1,L,L)      L1560
PRINT 25, NAME2(3), (YO(I),I=1,L,L)      L1570
PRINT 25, NAME3(1), (XBAR(I),I=1,L,L)      L1580
PRINT 25, NAME3(2), (YBAR(I),I=1,L,L)      L1590
PRINT 25, NAME2(4), (XS(I),I=1,L,L)      L1600
PRINT 25, NAME2(5), (YS(I),I=1,L,L)      L1610
PRINT 25, NAME3(3), (XSAR(I),I=1,L,L)      L1620
PRINT 25, NAME3(4), (YSAR(I),I=1,L,L)      L1630
PRINT 25, NAME2(6), (FTAS(I),I=1,L,L)      L1640
PRINT 25, NAME2(7), (BETAD(I),I=1,L,L)      L1650
PRINT 25, NAME2(8), (XI(I),I=1,L,L)      L1660
PRINT 25, NAME4(17), (CPSHOCK(I),I=1,L,L)      L1670
PRINT 25, NAME4(18), (CPBODY(I),I=1,L,L)      L1680
IF (NEXTRAP.EQ.1) GO TO 19      L1690
PRINT 25, NAME2(10), (UP(I),I=1,L,L)      L1700
PRINT 25, NAME2(12), (PR(I),I=1,L,L)      L1710
PRINT 25, NAME2(14), (VP(I),I=1,L,L)      L1720
PRINT 25, NAME2(11), (WP(I),I=1,L,L)      L1730
PRINT 25, NAME(14), (SBARP(I),I=1,L,L)      L1740
19 IF (LL.EQ.LIMIT) GO TO 20      L1750
IF (LIMIT.GT.LL.AND.LL.LE.10) GO TO 14      L1760
IF (LIMIT.GT.LL.AND.LL.LE.20) GO TO 15      L1770
IF (LIMIT.GT.LL.AND.LL.LE.30) GO TO 16      L1780
IF (LIMIT.GT.LL.AND.LL.LE.40) GO TO 17      L1790
20 PRINT 22      L1800
PRINT 21, (I,X(I),Y(I),ETA(I),ETASP(I),I=1,LIMIT)      L1810
PRINT 22      L1820
RETURN      L1830
C      L1840
C      L1850
21 FORMAT (3H I=14,2X,6HX(I)=E16,8,2X,6HX(I)=E16,8,2X,6HY(I)=E16,8      L1860
1,2X,6HTAS(I)=E16,8,2X,9HTASP(I)=E16,8)      L1870
22 FORMAT (/)      L1880
23 FORMAT (14X,3H1=9X,3H1=29X,3H1=39X,3H1=49X,3H1=59X,3H1=69X,3H1=79      L1890
1X,3H1=89X,3H1=99X,4H1=10/)      L1900
24 FORMAT (/14X,4H1=118X,4H1=128X,4H1=138X,4H1=148X,4H1=158X,4H1=168X      L1910
1,4H1=178X,4H1=188X,4H1=198X,4H1=20/)      L1920

PRINT 25, NAME(12), (G(I),I=1,L,L)      L1050
PRINT 25, NAME(13), (GONS(I),I=1,L,L)      L1060
PRINT 25, NAME(18), (AM(I),I=1,L,L)      L1070
PRINT 25, NAME(19), (CROSS(I),I=1,L,L)      L1080
PRINT 25, NAME(13), (SBAR(I),I=1,L,L)      L1090
PRINT 25, NAME(12), (POROGAM(I),I=1,L,L)      L1100
PRINT 25, NAME4(10), (PTOPT(I),I=1,L,L)      L1110
PRINT 25, NAME(13), (PT(I),I=1,L,L)      L1120
PRINT 25, NAME(15), (BERNOL(I),I=1,L,L)      L1130
IF (NEXTRAP.EQ.1) PRINT 25, NAME(9), (DVOZ(I),I=1,L,L)      L1140
IF (NEXTRAP.EQ.1) PRINT 25, NAME(7), (DPDZ(I),I=1,L,L)      L1150
IF (NEXTRAP.EQ.1) PRINT 25, NAME(11), (PP(I),I=1,L,L)      L1160
IF (NEXTRAP.EQ.1) PRINT 25, NAME(12), (UP(I),I=1,L,L)      L1170
IF (NEXTRAP.EQ.1) PRINT 25, NAME(14), (WP(I),I=1,L,L)      L1180
IF (NEXTRAP.EQ.1) GO TO 13      L1190
PRINT 25, NAME(7), (DPDZ(I),I=1,L,L)      L1200
PRINT 25, NAME(8), (DVOZ(I),I=1,L,L)      L1210
PRINT 25, NAME(9), (DVOZ(I),I=1,L,L)      L1220
PRINT 25, NAME(10), (DVOZ(I),I=1,L,L)      L1230
PRINT 25, NAME(13), (DSBZ(I),I=1,L,L)      L1240
PRINT 25, NAME(11), (PP(I),I=1,L,L)      L1250
PRINT 25, NAME(12), (UP(I),I=1,L,L)      L1260
PRINT 25, NAME(13), (WP(I),I=1,L,L)      L1270
PRINT 25, NAME(14), (WP(I),I=1,L,L)      L1280
PRINT 25, NAME(14), (SBARP(I),I=1,L,L)      L1290
13 IF (LL.EQ.LIMIT) RETURN      L1300
IF (LIMIT.GT.LL.AND.LL.LE.10) GO TO 14      L1310
IF (LIMIT.GT.LL.AND.LL.LE.20) GO TO 15      L1320
IF (LIMIT.GT.LL.AND.LL.LE.30) GO TO 16      L1330
IF (LIMIT.GT.LL.AND.LL.LE.40) GO TO 17      L1340
14 LB=LL+1      L1350
IF (LIMIT.GT.20) LL=20      L1360
PRINT 24      L1370
GO TO (12,18), LPRINT      L1380
15 LB=LL+1      L1390
IF (LIMIT.GT.30) LL=LIMIT      L1400
IF (LIMIT.GT.30) LL=30      L1410
PRINT 26      L1420
GO TO (12,18), LPRINT      L1430
16 LB=LL+1      L1440
IF (LIMIT.GT.40) LL=LIMIT      L1450
IF (LIMIT.GT.40) LL=40      L1460
PRINT 27      L1470

25 FORMAT (1X1A10,10E12,4)      L1930
26 FORMAT (/14X,4H1=218X,4H1=228X,4H1=238X,4H1=248X,4H1=258X,4H1=268X      L1940
1,4H1=278X,4H1=288X,4H1=298X,4H1=30/)      L1950
27 FORMAT (/14X,4H1=318X,4H1=328X,4H1=338X,4H1=348X,4H1=358X,4H1=368X      L1960
1,4H1=378X,4H1=388X,4H1=398X,4H1=40/)      L1970
28 FORMAT (/14X,4H1=418X,4H1=428X,4H1=438X,4H1=448X,4H1=458X,4H1=468X      L1980
1,4H1=478X,4H1=488X,4H1=498X,4H1=50/)      L1990
29 FORMAT (5E16,8)      L2000
30 FORMAT (/55X,19HSUMMARY PRINT BLOCK//)      L2010
END      L2020
SUBROUTINE FNCOEFS (LIMIT,NB,NSPACE,XI,A,N,AA,AAA,P,A2,A1,AA,GY      L2030
1,YO,SINALP,COSALP)      L2040
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C      L9780
C      L9790
C      L9800
C      L9810
C      L9820
C      L9830
C      L9840
C      L9850
C      L9860
C      L9870
C      L9880
C      L9890
C      L9900
C      L9910
C      L9920
C      L9930
C      L9940
C      L9950
C      L9960
C      L9970
C      L9980
C      L9990

```

APPENDIX B

```

SUM3=0.0
NCOMP=3
DX13=X1(LIMIT)-X1(LIMIT-1)
DO 7 I=NB,LIMIT
GO TO 11
6 CONTINUE
7 CONTINUE
AINT7=DX13/3.*SUM1
AINT8=DX13/3.*SUM2
AINT9=DX13/3.*SUM3
GO TO (8,9), NSPACE
8 CZ=2./A*AIINT7
CY=-2./A*AIINT8
IF (M.EQ.3) YBRR=0.0
IF (M.NE.3) YBRR=4./((3.*A*CZ)*AINT9
GO TO 10
9 CZ=2./A*(AINT1+AINT4+AINT7)
CY=-2./A*(AINT2+AINT5+AINT8)
IF (M.EQ.3) YBRR=0.0
IF (M.NE.3) YBRR=4./((3.*A*CZ)*(AINT3+AINT6+AINT9)
10 CD=CZ*COSALP+CY*SINALP
CL=-CZ*SINALP+CY*COSALP
ZBAR=2./3.
CM=YBRR*CZ-ZBAR*CY
PRINT 14
PRINT 12, CZ,CY,CD,CL
PRINT 13, YBRR,ZBAR,CM
RETURN
11 AAA=PI()-AA
DENOM=SQRT(A2(I))
QUAN1=AAA*A4(I)*A1(I)/DENOM
QUAN2=AAA*GY(I)*A1(I)/DENOM
QUAN3=QUAN1*YO(I)
IF (MOD(I,2).EQ.0) FACT=A.0
IF (MOD(I,2).NE.0) FACT=2.0
IF (I.EQ.1.OR.I.EQ.NA.OR.I.EQ.NB.OR.I.EQ.LIMIT) FACT=1.0
SUM1=SUM1+FACT*QUAN1
SUM2=SUM2+FACT*QUAN2
SUM3=SUM3+FACT*QUAN3
GO TO (1,3,6), NCOMP
C
12 FORMAT (4H CZ=E16.8,2X,3HCY=E16.8,2X,3HCD=E16.8,2X,3HCL=E16.8)
13 FORMAT (6H YBAR=E16.8,2X,5HZBAR=E16.8,2X,3HCM=E16.8//)
C
14 FORMAT (/50X,19H FORCE COEFFICIENTS/)
END
SUBROUTINE SIMEQ (A,N,B,M,DETERM,PIVOT,NMAX,ISCALE)
C
C SOLUTION OF SIMULTANEOUS LINEAR EQUATIONS
C
C DIMENSION PIVOT(N), A(NMAX,N), B(NMAX,M)
C EQUIVALENCE (IROW,JROW), (ICOLU,JCOLU), (AMAX,T,SWAP)
C
C INITIALIZATION
C
1 ISCALE=0
R1=1.0/PIVOT
R2=1.0/R1
DETERM=1.0
DO 2 J=1,N
2 PIVOT(J)=0
DO 3B I=1,M
3 B(I,J)=1.0
C
C SEARCH FOR PIVOT ELEMENT
C
AMAX=0.0
DO 7 J=1,N
IF (PIVOT(J)-1) 3,7,3
3 DO 6 K=1,N
IF (PIVOT(K)-1) 4,6,39
4 IF (ABS(AMAX)-ABS(A(J,K))) 5,6,6
5 IROW=J
ICOLU=K
AMAX=A(J,K)
6 CONTINUE
7 CONTINUE
IF (AMAX) 9,8,9
8 DETERM=0.0
ISCALE=0
GO TO 39
9 PIVOT(ICOLU)=PIVOT(ICOLU)+1
C
C INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
IF (IROW-ICOLU) 10,14,10
10 DETERM=-DETERM
DO 11 L=1,N
SWAP=A(IROW,L)
M 350 A(IROW,L)=A(ICOLU,L)
M 360 11 A(ICOLU,L)=SWAP
M 370 IF (M) 14,14,12
M 380 12 DO 13 L=L+1,M
M 390 SWAP=B(IROW,L)
M 400 B(IROW,L)=B(ICOLU,L)
M 410 13 B(ICOLU,L)=SWAP
M 420 14 PIVOT=A(ICOLU,ICOLU)
M 430 IF (PIVOT) 15,8,15
M 440 C
M 450 C SCALE THE DETERMINANT
M 460 C
M 470 15 PIVOT=PIVOT
M 480 IF (ABS(DETERM)-R1) 18,16,16
M 490 16 DETERM=DETERM/R1
M 500 ISCALE=ISCALE+1
M 510 IF (ABS(DETERM)-R1) 21,17,17
M 520 17 DETERM=DETERM/R1
M 530 ISCALE=ISCALE+1
M 540 GO TO 21
M 550 18 IF (ABS(DETERM)-R2) 19,19,21
M 560 19 DETERM=DETERM/R1
M 570 ISCALE=ISCALE+1
M 580 IF (ABS(DETERM)-R2) 20,20,21
M 590 20 DETERM=DETERM/R1
M 600 ISCALE=ISCALE+1
M 610 21 IF (ABS(PIVOT)-R1) 24,22,22
M 620 22 PIVOT=PIVOT/R1
M 630 ISCALE=ISCALE+1
M 640 IF (ABS(PIVOT)-R1) 27,23,23
M 650 23 PIVOT=PIVOT/R1
M 660 ISCALE=ISCALE+1
M 670 GO TO 27
M 680 24 IF (ABS(PIVOT)-R2) 25,25,27
M 690 25 PIVOT=PIVOT/R1
M 700 ISCALE=ISCALE+1
M 710 IF (ABS(PIVOT)-R2) 26,26,27
M 720 26 PIVOT=PIVOT/R1
M 730 ISCALE=ISCALE+1
M 740 27 DETERM=DETERM*PIVOT
M 750 C
M 760 C DIVIDE PIVOT ROW BY PIVOT ELEMENT
M 770 C
M 780 DO 29 L=1,N
N 430 A(IROW,L)=A(ICOLU,L)
N 440 11 A(ICOLU,L)=SWAP
N 450 IF (M) 14,14,12
N 460 12 DO 13 L=L+1,M
N 470 SWAP=B(IROW,L)
N 480 B(IROW,L)=B(ICOLU,L)
N 490 13 B(ICOLU,L)=SWAP
N 500 14 PIVOT=A(ICOLU,ICOLU)
N 510 IF (PIVOT) 15,8,15
N 520 C
N 530 C SCALE THE DETERMINANT
N 540 C
N 550 15 PIVOT=PIVOT
N 560 IF (ABS(DETERM)-R1) 18,16,16
N 570 16 DETERM=DETERM/R1
N 580 ISCALE=ISCALE+1
N 590 IF (ABS(DETERM)-R1) 21,17,17
N 600 17 DETERM=DETERM/R1
N 610 ISCALE=ISCALE+1
N 620 GO TO 21
N 630 18 IF (ABS(DETERM)-R2) 19,19,21
N 640 19 DETERM=DETERM/R1
N 650 ISCALE=ISCALE+1
N 660 IF (ABS(DETERM)-R2) 20,20,21
N 670 20 DETERM=DETERM/R1
N 680 ISCALE=ISCALE+1
N 690 21 IF (ABS(PIVOT)-R1) 24,22,22
N 700 22 PIVOT=PIVOT/R1
N 710 ISCALE=ISCALE+1
N 720 IF (ABS(PIVOT)-R1) 27,23,23
N 730 23 PIVOT=PIVOT/R1
N 740 ISCALE=ISCALE+1
N 750 GO TO 27
N 760 24 IF (ABS(PIVOT)-R2) 25,25,27
N 770 25 PIVOT=PIVOT/R1
N 780 ISCALE=ISCALE+1
N 790 IF (ABS(PIVOT)-R2) 26,26,27
N 800 26 PIVOT=PIVOT/R1
N 810 ISCALE=ISCALE+1
N 820 27 DETERM=DETERM*PIVOT
N 830 C
N 840 C DIVIDE PIVOT ROW BY PIVOT ELEMENT
N 850 C
N 860 DO 29 L=1,N
N 870 IF (PIVOT(L)-1) 28,29,39
N 880 28 A(ICOLU,L)=A(ICOLU,L)/PIVOT
N 890 29 CONTINUE
N 900 IF (M) 32,32,30
N 910 30 DO 31 L=L+1,M
N 920 31 B(ICOLU,L)=B(ICOLU,L)/PIVOT
N 930 C
N 940 C REDUCE NON-PIVOT ROWS
N 950 C
N 960 32 DO 38 L=1,N
N 970 IF (L-ICOLU) 33,38,33
N 980 33 T=A(L,ICOLU)
N 990 DO 35 L=L+1,N
N 1000 34 A(L,L)=A(L,L)-T*A(ICOLU,L)+T
N 1010 35 CONTINUE
N 1020 IF (M) 38,38,36
N 1030 36 DO 37 L=L+1,M
N 1040 37 B(L,L)=B(L,L)-T*B(ICOLU,L)+T
N 1050 38 CONTINUE
N 1060 39 RETURN
N 1070 END
N 1080- FUNCTION DIF (L,M,NP,VARI,VARD)
O 10
O 20 THIS FUNCTION SUBPROGRAM FINDS THE DERIVATIVE AT A GIVEN POINT,
O 30 L, FOR THE DESIRED X AND Y IN A GIVEN TABLE. THE N-POINT
O 40 LAGRANGIAN FORMULA IS USED WHERE N IS ODD.
O 50
O 60 L = INTEGER, THE POINT OF X AND Y AT WHICH DERIVATIVE IS FOUND
O 70 N = INTEGER, 1-5, TO DETERMINE THE POINT FORMULA. N = 2*M+1
O 80 NP = INTEGER, THE NUMBER OF POINTS IN TABLE OF VARIABLES
O 90 VARI = ARRAY OF INDEPENDENT VARIABLE, X. VARI(NP)
O 100 VARD = ARRAY OF DEPENDENT VARIABLE, Y. VARD(NP)
O 110
O 120 DIMENSION VARI(NP), VARD(NP), X(1), Y(1)
O 130
O 140 DIF=0.17770000000000000000
O 150 IF (M.LT.1) RETURN
O 160 N=2*M+1
O 170 IF (M.GT.5.OR.N.GT.NP) RETURN
O 180 M1=M+1
O 190 M2=NP-M+1
O 200 K=L
O 210 IF (L.LE.M1.OR.N.EQ.NP) GO TO 1
O 220

```

APPENDIX B

<pre> K=M) IF (L+LT+R2) GO TO 1 K=L-(M*P-N) 1 NX=L-K DO 2 J=1,N MJ=MX+J X(J)=VARI(MJ) 2 Y(J)=VARD(MJ) A=1. B=0. C=0. DO 4 J=1,N IF (J+EQ+K) GO TO 4 P=L DO 3 I=1,N IF (I+EQ+J) GO TO 3 PMP=X(J)-X(I) 3 CONTINUE T=X(K)-X(J) B=B+Y(J)/(P*T) A=A*T C=C+1./T 4 CONTINUE DIF=A*B+Y(K)*C RETURN END </pre>	<pre> 0 230 0 240 0 250 0 260 0 270 0 280 0 290 0 300 0 310 0 320 0 330 0 340 0 350 0 360 0 370 0 380 0 390 0 400 0 410 0 420 0 430 0 440 0 450 0 460 0 470 0 480- </pre>
---	---

APPENDIX B

Subroutines

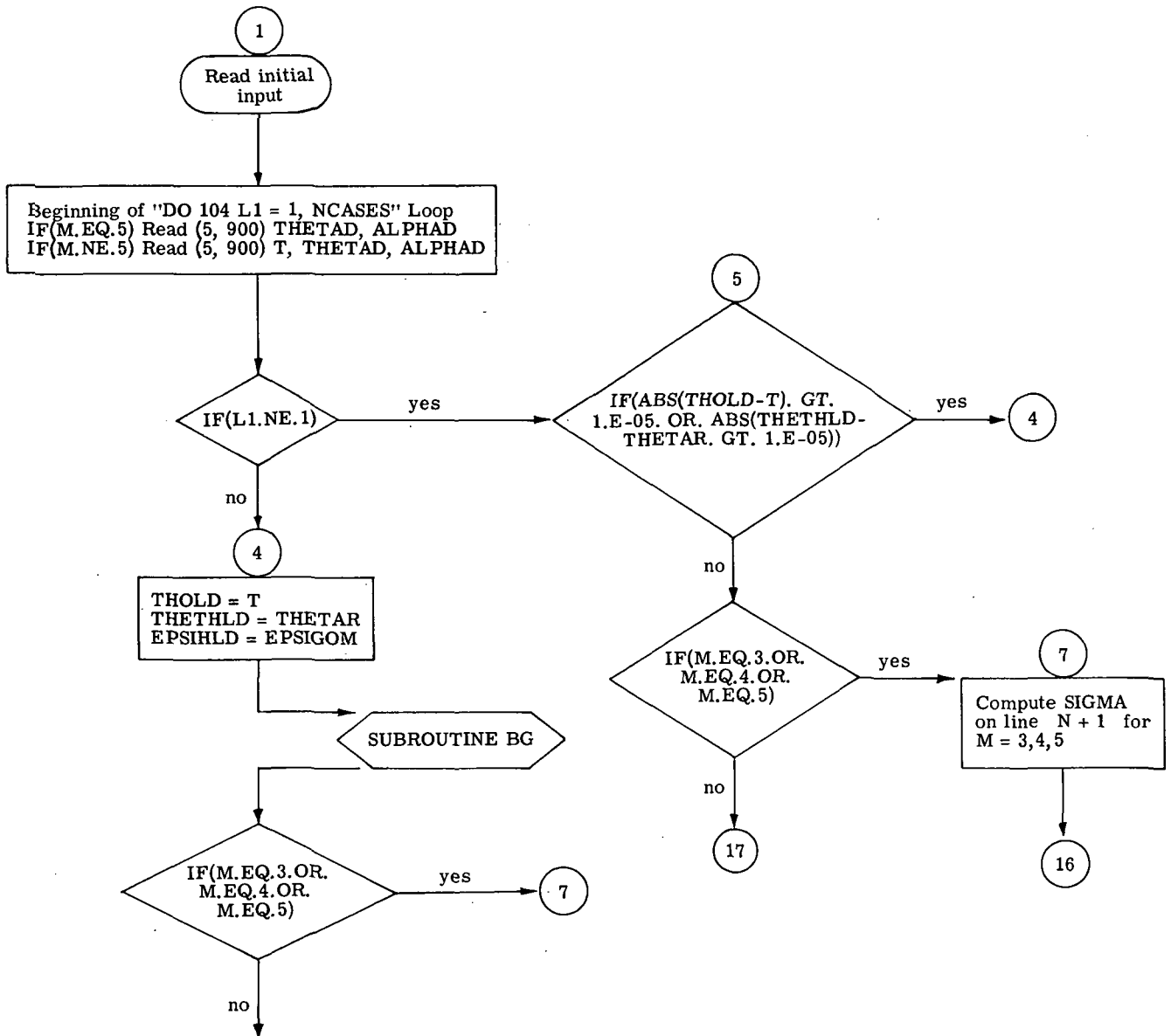
A list of the subroutines used in this program is presented.

<u>FORTRAN name</u>	<u>Called by</u>	<u>Function</u>
BG	MAIN	Executive subroutine for computation of body geometry
RUNKUT	BG	Runge-Kutta integration for body geometry
DERIV	BG RUNKUT	Computation of derivatives for body-geometry integration
APPROX	MAIN	Computation of approximate shock shape for NREAD = 0
LGRANGE	MAIN DERIV2	Establishes line arrangement, accounting for symmetry where appropriate, for computation of ξ -derivatives for function DIF
DIRCOS	MAIN	Computation of direction cosines of r -, η -, τ -coordinates
SHOCK	MAIN	Computation of flow quantities behind shock
DERIV2	MAIN RUNKUT2	Executive subroutine for computation of derivatives for integration of equations
EQNS	DERIV2	Computation of ξ -derivatives for integration of equations
RUNKUT2	MAIN	Runge-Kutta integration of equations
PRINT	MAIN	Print instructions
FMCOEFS	MAIN	Computation of force and moment coefficients
SIMEQ	MAIN	Solution of simultaneous linear equations to evaluate corrections $\Delta\eta$ to the shock shape
DIF	LGRANGE	Computation of derivatives from the Lagrange formula

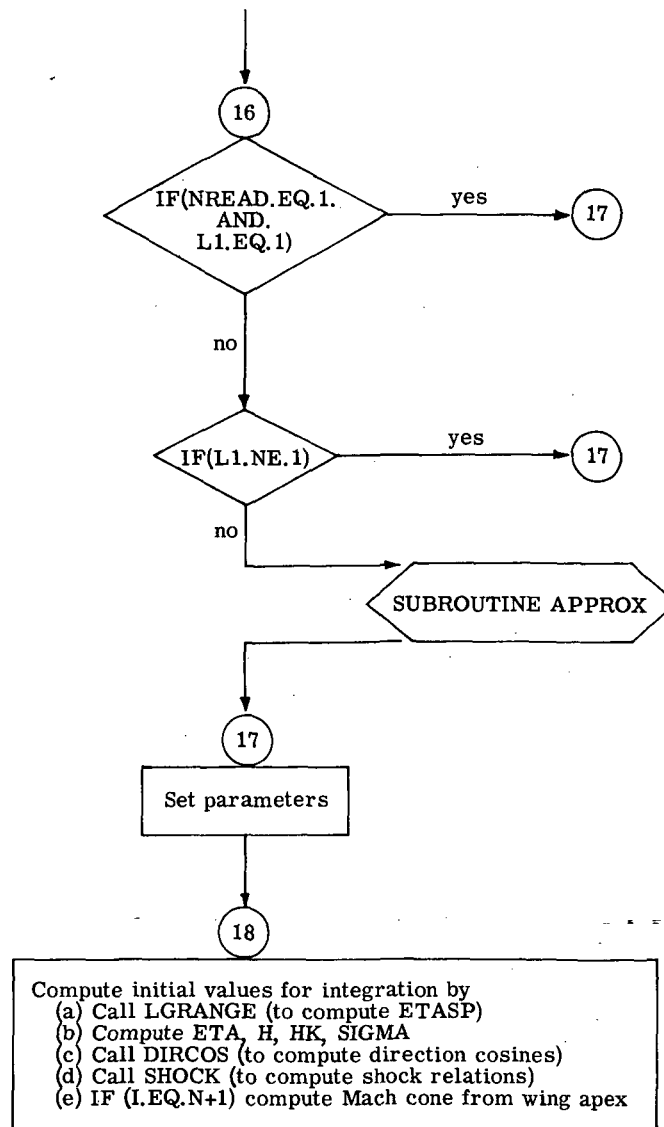
APPENDIX B

Flow Chart

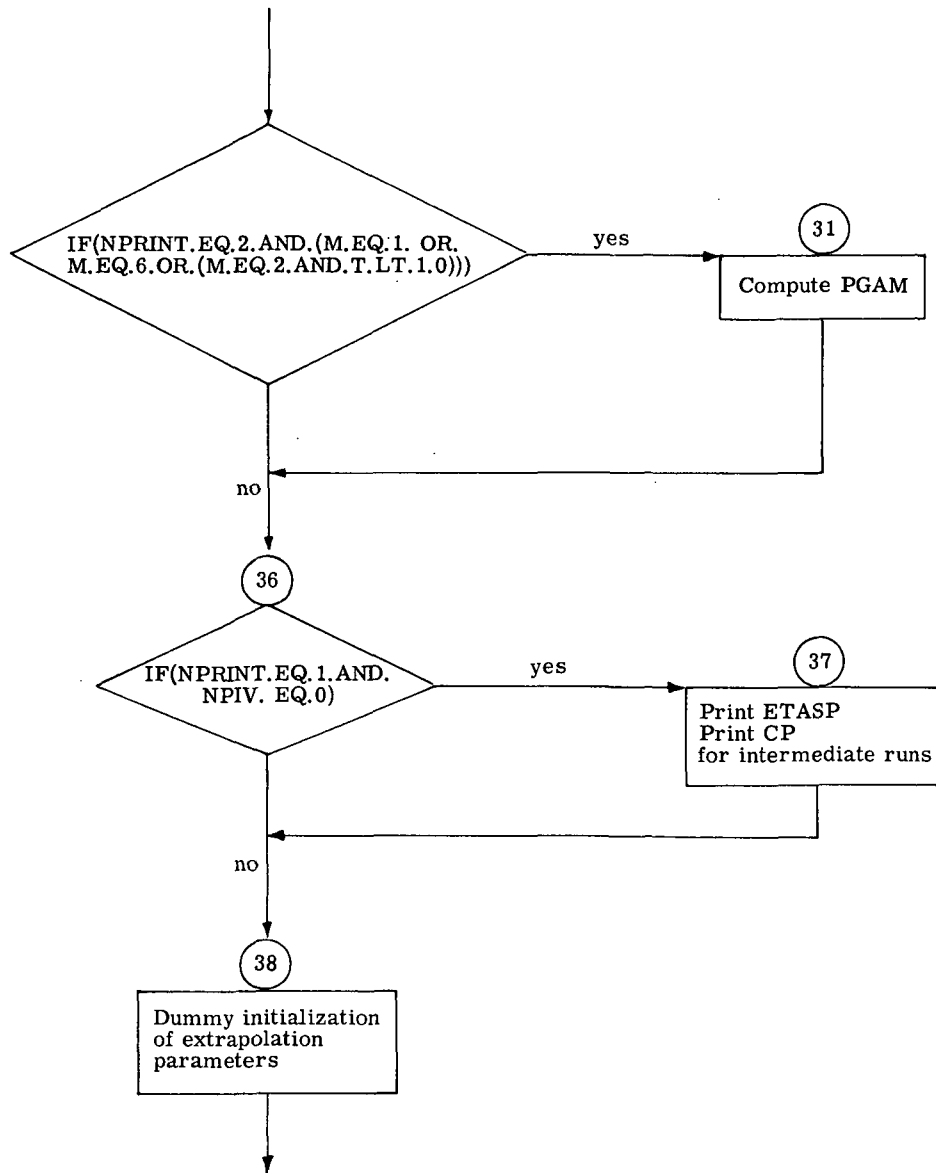
A flow chart of the computer program is given:



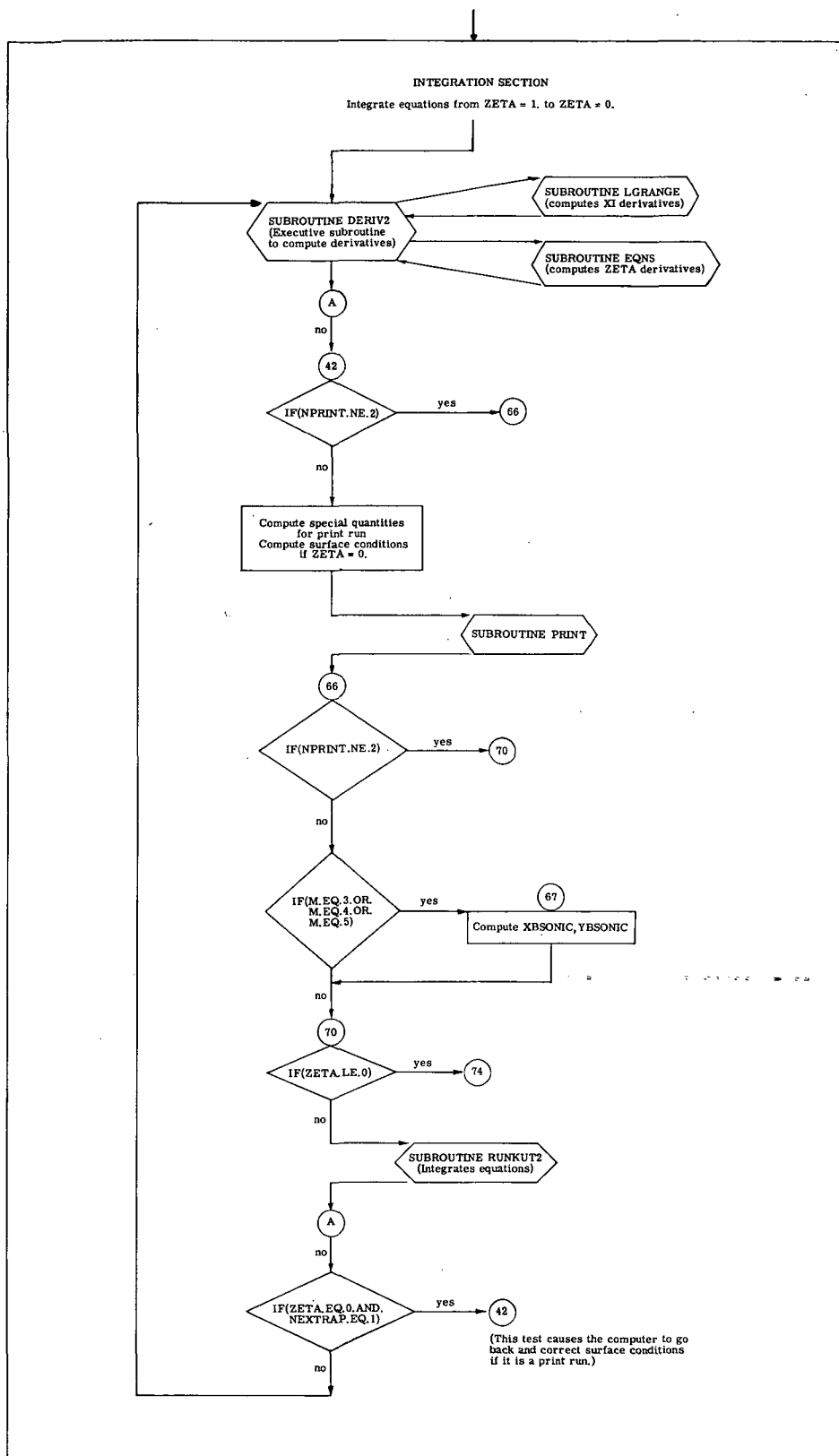
APPENDIX B



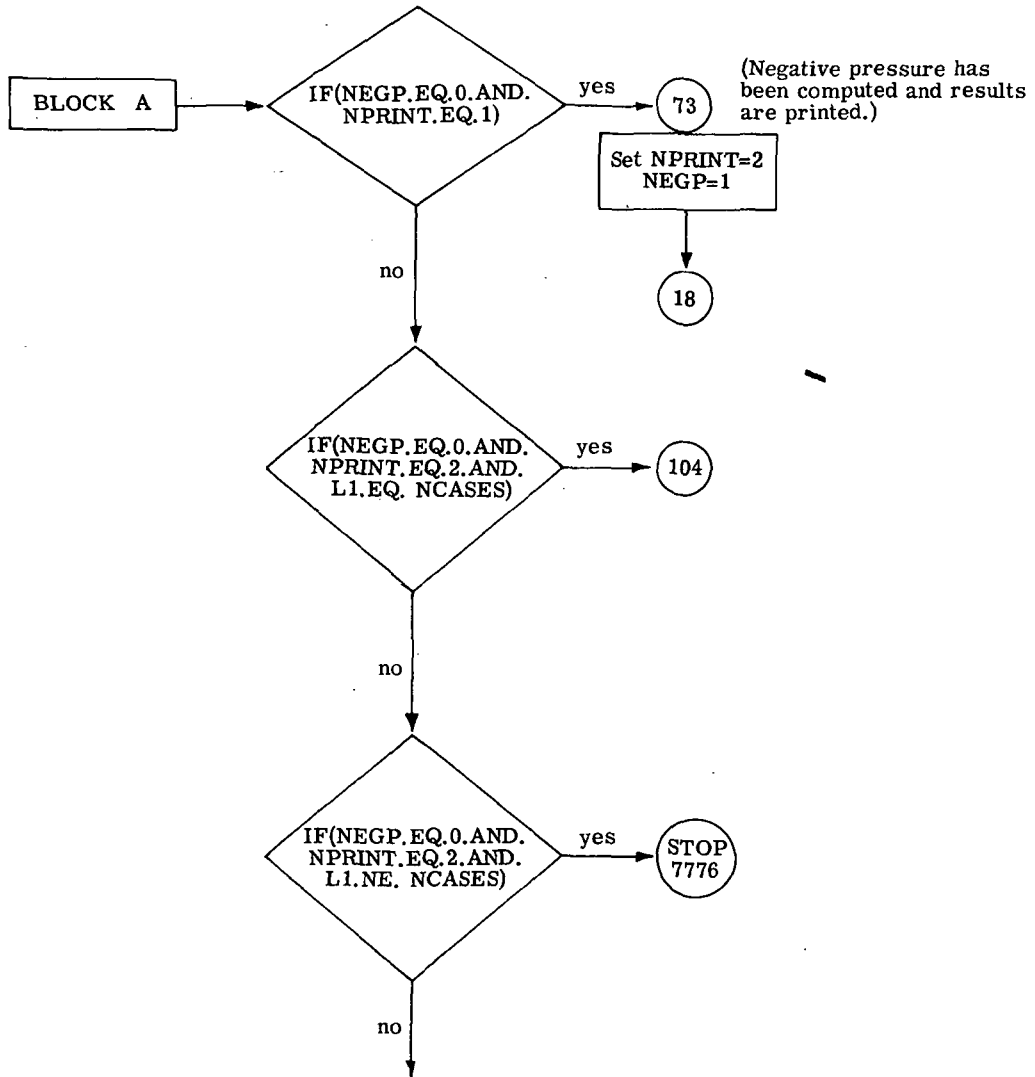
APPENDIX B



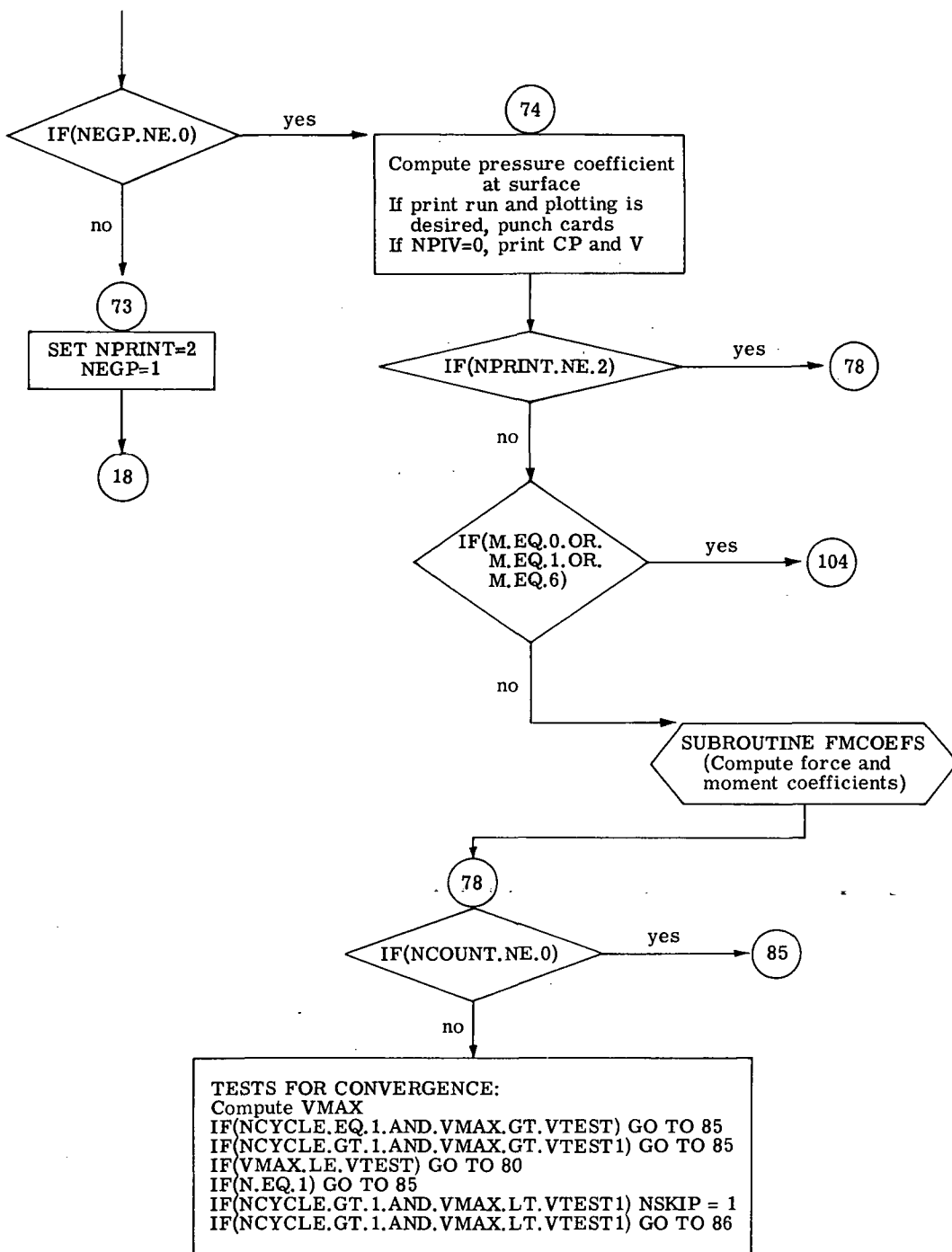
APPENDIX B



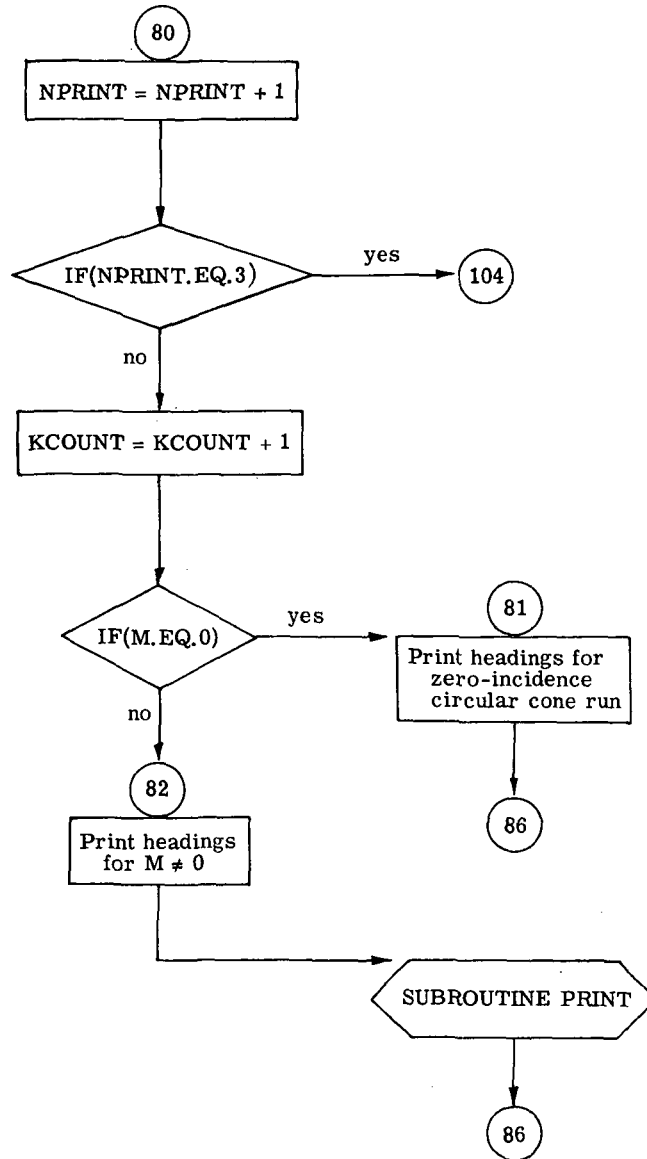
APPENDIX B



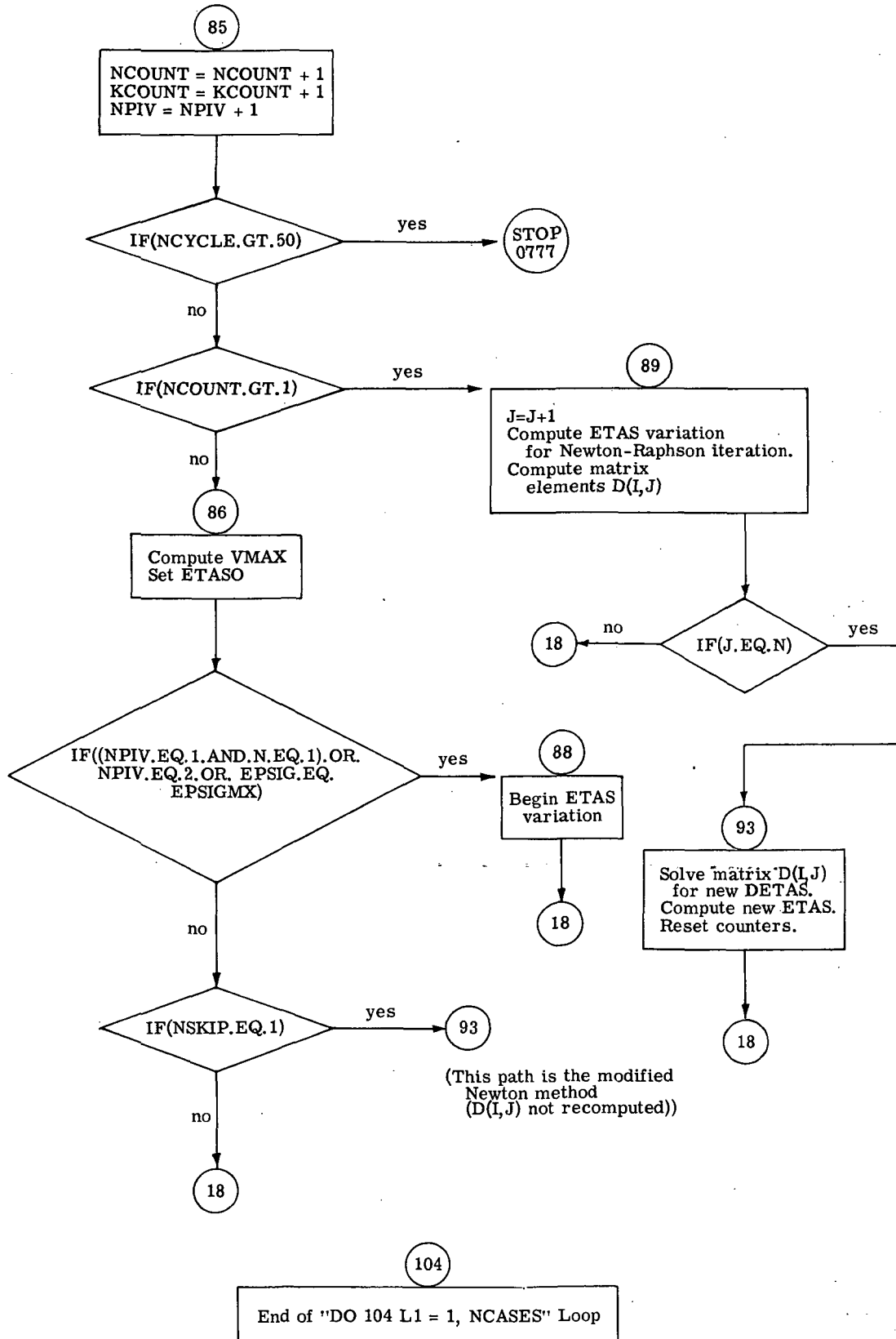
APPENDIX B



APPENDIX B



APPENDIX B



APPENDIX C

SAMPLE COMPUTATION

A sample computation, which required 63 seconds on the Control Data series 6600 computer system, is presented for a conical wing of circular-arc cross section. The input is

<u>Input card no.</u>	<u>Input</u>
1	STMACH = 4.0, GAMMA = 1.4
2	N = 8, M = 4, NCASES = 1, NREAD = 0, NSPACE = 1, NPLOT = 0, NPUNCH = 0
3	VTESTHD = 0.001, VTEST1 = 0.03
4	T = 0.06, THETAD = 40.0, ALPHAD = 5.0

Explanations of sections of the sample-computation output are provided at the end of this appendix. Circled numbers at the left side of each section indicate the appropriate explanatory note.

Input Cards for Sample Computation

```

40000000+01  14000000+01
  8    4    1    0    1    0    0
.001          .03
60000000-01  40000000+02  50000000+01

```

Conical Flow by the Method of Lines

```

N= 3  M=4  NREAD=0  NSPACE=1  NP= 5
NA= 1  ANA= 0.      NB= 1  BNB= 0.
VTEST= 1.00000000E-03  VTEST1= 3.00000000E-02

```

APPENDIX C

10/18/71 CS.36.34.

1

STMACH= 4.0000000E+00 GAMMA= 1.4CCCC000E+00 T= 6.0000000E-02 TETA0= 4.0000000E+01 ALPHAD= 5.0000000E+00

EPSIGCM= 1.0000000E-03

AAST= 4.67707173E-01 PTINF= 4.77835753E+00

IATCNT= 430 XINI= 7.00138440E-C1

DELTA(N+1)= 1.66854120E+C1 BETA(SONIC)= 6.28541702E+01 DELTA(SONIC)= 3.05521391E+C1

BETA(DELTA)= 6.48525564E+01 CELTA(DELTA)= 3.06670273E+01

BETAC(N+1)= 3.78356441E+01 SIGMAC= 2.11502315E+01 VNS= 6.46245696E-C1 AMN= 2.58498278E+00

NCVCL= 1 AT 10/18/71 CS.36.35.

2

ETAS

1.90074822E-01 1.86264468E-01 1.74993468E-01 1.56742131E-C1 1.32310811E-01 1.02820109E-01 6.97107713E-02 3.47437090E-02

ETASP

-3.97505029E-15 -8.67717320E-02 -1.69885150E-01 -2.45681939E-C1 -3.10503766E-01 -3.60692377E-C1 -3.92589397E-01 -3.98268498E-01

CP(1) AT SHCCK

6.84404208E-02 7.09433824E-C2 7.82311578E-C2 8.96587168E-02 1.04184704E-01 1.20390004E-01 1.36472568E-01 1.47911371E-01

CP(1) AT ZETA=0

7.81534261E-02 7.67719052E-02 6.04518587E-02 8.29055452E-02 8.80157326E-02 9.35569747E-02 1.09247799E-01 1.33933437E-01

CP(1) AT ZETA=0

1.57125710E-01

V

-1.02724371E-02 -1.54861064E-C2 -2.44455176E-02 -3.17337925E-02 -3.62433711E-02 -4.07820733E-02 -2.97161930E-02 -9.89687667E-03

KCCUNT= 1 VMAX= 4.07620733E-C2 EPSIG= 1.0000000E-03 SPACER= 1.0000000E-03 EPSIVAR= 1.0000000E-06

ISCALE= 0 DETERM= 1.85186886E-02

3

DETA

7.18930322E-03 7.47952900E-03 8.34519596E-03 7.43707953E-03 4.42494704E-03 1.34561885E-03 7.04132522E-04 -3.98756129E-04

NCVCL= 2 AT 10/18/71 CS.36.35.

4

ETAS

1.57264125E-01 1.93743957E-01 1.83338684E-01 1.64175211E-01 1.36735758E-01 1.04165728E-01 7.04149038E-02 3.43449528E-02

ETASP

-2.672635175E-15 -7.79262519E-02 -1.67576308E-01 -2.69703933E-C1 -3.49625977E-01 -3.81574609E-01 -4.01663843E-01 -4.02251317E-01

CP(1) AT SHCCK

7.58102710E-02 7.80624240E-02 6.65356758E-02 1.01746897E-01 1.18450901E-01 1.28508494E-01 1.40825104E-01 1.49516954E-01

CP(1) AT ZETA=0

8.4064049E-02 8.37485479E-C2 6.56806905E-02 9.30605938E-02 1.06533517E-01 1.13594297E-01 1.23730702E-01 1.39557589E-01

CP(1) AT ZETA=0

1.57125710E-01

V

-2.32372523E-03 -3.81062426E-03 2.34943304E-03 6.09321769E-03 1.24512301E-03 -4.72590541E-03 -4.40879567E-03 -8.84720008E-04

KCCUNT= 5 VMAX= 6.09321769E-C3 EPSIG= 1.0000000E-03 SPACER= 1.0000000E-03 EPSIVAR= 1.0000000E-06

ISCALE= 0 DETERM= 1.85186886E-02

5

DETA

4.02272398E-04 -1.63631557E-04 4.52267928E-04 2.62971557E-04 1.06839548E-C3 -5.53215907E-04 1.67068287E-04 -5.74513474E-04

NCVCL= 3 AT 10/18/71 CS.39.37.

6

ETAS

1.57666358E-01 1.93580345E-01 1.83790552E-01 1.64442182E-C1 1.37804158E-01 1.03612512E-01 7.05819721E-02 3.37704394E-02

ETASP

-2.69521829E-15 -7.79516172E-02 -1.64960922E-01 -2.64639566E-01 -3.55575754E-01 -3.87643089E-01 -4.00808756E-01 -4.03245804E-01

CP(1) AT SHCCK

7.62264506E-02 7.78946904E-C2 8.66774086E-02 1.01102963E-01 1.20955818E-01 1.29884031E-01 1.40644918E-01 1.49449640E-01

CP(1) AT ZETA=0

8.47921732E-02 8.44352046E-C2 6.65225197E-02 8.98196485E-02 1.05151827E-01 1.16730671E-01 1.25637082E-01 1.40012675E-01

CP(1) AT ZETA=0

1.57125710E-01

V

-2.92087468E-03 -1.56491204E-04 -3.14765099E-03 1.21330423E-04 3.29330426E-03 -3.26140127E-04 -1.15092288E-03 -3.62743993E-04

KCCUNT= 9 VMAX= 3.29330426E-C3 EPSIG= 1.0000000E-03 SPACER= 1.0000000E-03 EPSIVAR= 1.0000000E-06

ISCALE= 0 DETERM= 1.85186886E-02

7

DETA

5.58381074E-05 -7.25714687E-C6 5.33015996E-05 8.37617954E-C6 3.67281034E-C4 2.33780010E-04 -4.14470139E-05 2.85154590E-04

NCVCL= 4 AT 10/18/71 CS.39.39.

8

ETAS

1.57726236E-01 1.93573108E-01 1.83884253E-01 1.64450555E-C1 1.38171439E-01 1.03846292E-01 7.05405251E-02 3.40555940E-02

ETASP

-6.88787742E-15 -7.77115936E-02 -1.65134580E-01 -2.62782030E-01 -3.53730424E-01 -3.91020138E-01 -4.00067686E-01 -4.03009011E-01

CP(1) AT SHCCK

7.62264506E-02 7.78716483E-C2 8.67963858E-02 1.00772543E-01 1.20934037E-01 1.31193563E-01 1.40305642E-01 1.49559337E-01

CP(1) AT ZETA=0

8.45457920E-02 8.41691562E-C2 6.71888517E-02 9.05804585E-02 1.03133691E-01 1.17084420E-01 1.26363302E-01 1.40176250E-01

CP(1) AT ZETA=0

1.57125710E-01

V

-1.11747769E-03 1.13142544E-03 -1.68077764E-04 -1.51505352E-03 7.66523111E-04 7.49407610E-04 -1.39387242E-04 -1.57485000E-05

KCCUNT= 9 VMAX= 1.51505352E-C3 EPSIG= 1.0000000E-03 SPACER= 1.0000000E-03 EPSIVAR= 1.0000000E-06

ISCALE= 0 DETERM= 1.85186886E-02

9

DETA

1.27806226E-05 1.03219190E-C4 -7.40353469E-05 1.08638526E-04 -7.34754554E-C5 3.17454440E-04 -8.71735178E-05 2.82061778E-04

NCVCL= 5 AT 10/18/71 CS.39.30.

10

ETAS

1.57653455E-01 1.93676327E-01 1.83810218E-01 1.64559157E-C1 1.38097563E-01 1.04163747E-01 7.04533516E-02 3.43376557E-02

ETASP

-1.56592519E-15 -7.77263118E-02 -1.65092636E-01 -2.62981758E-01 -3.52127250E-C1 -3.51289616E-01 -4.00407253E-01 -4.02510975E-01

CP(1) AT SHCCK

7.62132576E-02 7.79794306E-C2 8.67140648E-02 1.00922343E-01 1.20470561E-01 1.31610735E-01 1.40356878E-01 1.49617978E-01

CP(1) AT ZETA=0

8.45442700E-02 8.42022677E-C2 6.6755019E-02 9.13056476E-02 1.02859553E-01 1.16611576E-01 1.26561459E-01 1.40185412E-01

CP(1) AT ZETA=0

1.57125710E-01

V

-3.56091489E-04 1.37705286E-04 4.02041730E-04 -3.57441640E-04 -3.81899463E-04 4.45118496E-04 7.87970758E-05 6.76067275E-05

KCCUNT= 9 VMAX= 1.37705286E-04 EPSIG= 1.0000000E-03 SPACER= 1.0000000E-03 EPSIVAR= 1.0000000E-06

ISCALE= 0 DETERM= 1.85186886E-02

APPENDIX C

11 N= 8 M=4 NFEAD=0 NSPACE=1 AP= 5
NA= 1 ZNA= 0. N= 1 ENB= 0.
STMACH= 4.CCCCC000E+00 GAMMA= 1.4CCCC000E+00 T= 6.CCCCC000E+02 TFEAD= 4.00000000E+01 ALP+AD= 5.00000000E+00
NCYCLE= 5 NSTEP= 1 VTEST= 1.CCCCC000E+03 VMAX= 4.45118496E+04 AAST= 4.67707173E+01 PTINF= 6.77835793E+00
KCLLAT= 10 VMAX= 4.45118496E+04 EPSIG= 1.00000000E+03 SPACER= 1.CCCCC000E+03 EPSIVAR= 1.00000000E+06
DELTA(N+1)= 1.CCE54126E+01 DELTA(SONIC)= 4.2E541702E+01 DELTA(SONIC)= 3.05521391E+01
DELTA(UT)= 6.48525564E+01 DELTA(UT)= 3.C6670273E+01
12 BETACIN(1)= 2.35537002E+01 SIG/D= 2.11502315E+01 VNS= 0.40245696E+01 AMN= 2.58498278E+00
NJ= 1 XMAC= 4.07375024E+01 YMAC= 0. XMACH= 4.85496368E+01 YMACH= 0.
NJ= 2 XMAC= 4.1250741E+01 YMAC= -1.09155824E+02 XMACH= 4.92135529E+01 YMACH= -2.25431900E+02
NJ= 3 XMAC= 4.1734142E+01 YMAC= -3.78315648E+02 XMACH= 4.97368147E+01 YMACH= -4.50863800E+02
NJ= 4 XMAC= 4.2057333E+01 YMAC= -5.67479472E+02 XMACH= 5.01248383E+01 YMACH= -6.76255699E+02
NJ= 5 XMAC= 4.22750251E+01 YMAC= -7.56635256E+02 XMACH= 5.03614131E+01 YMACH= -9.01727599E+02
NJ= 6 XMAC= 4.23320037E+01 YMAC= -9.45759120E+02 XMACH= 5.05085632E+01 YMACH= -1.12715950E+03
NJ= 7 XMAC= 4.23815620E+01 YMAC= -1.1345854E+03 XMACH= 5.05083787E+01 YMACH= -1.35259140E+03
NJ= 8 XMAC= 4.2273544E+01 YMAC= -1.32411377E+03 XMACH= 5.03756465E+01 YMACH= -1.57802330E+03
NJ= 9 XMAC= 4.20567357E+01 YMAC= -1.51327859E+03 XMACH= 5.01212706E+01 YMACH= -1.8034552E+03
NJ=10 XMAC= 4.17261158E+01 YMAC= -1.70243642E+03 XMACH= 4.97304709E+01 YMACH= -2.02888710E+03
NJ=11 XMAC= 4.12602199E+01 YMAC= -1.87159824E+03 XMACH= 4.9203009E+01 YMACH= -2.25431900E+03

SUMMARY PRINT HLCCX

13 I=1 I=2 I=3 I=4 I=5 I=6 I=7 I=8 I=9 I=10
PSID -9.0000E+01 -2.9547E+01 -1.5204E+01 -9.5376E+00 -6.3797E+00 -4.2485E+00 -2.6166E+00 -1.2443E+00 1.4471E-08
PSID -9.0000E+01 -6.5890E+01 -1.2487E+01 -3.8212E+01 -2.6808E+01 -1.7480E+01 -1.0408E+01 -4.6061E+00 1.4471E-08
XC 0. 8.7848E+02 1.7703E+01 2.6846E+01 3.6522E+01 4.6770E+01 5.7869E+01 7.0116E+01 8.3910E+01
YC -0.0346E+02 1.7703E+01 2.6846E+01 3.6522E+01 4.6770E+01 5.7869E+01 7.0116E+01 8.3910E+01 1.1193E+10
XGBAR 0. 1.0469E+01 1.1586E+01 3.2053E+01 4.3526E+01 5.5738E+01 6.8965E+01 8.3562E+01 1.0000E+02
YGBAR -6.0000E+02 -3.9451E+02 -5.7339E+02 -5.3055E+02 -4.8566E+02 -4.1406E+02 -3.1517E+02 -1.8150E+02 2.5256E+10
XS 0. 9.1226E+02 1.8361E+01 2.7620E+01 3.7624E+01 4.7901E+01 5.8894E+01 7.0786E+01 8.3910E+01
YS -2.5317E+01 -2.4915E+01 -2.3518E+01 -2.1901E+01 -1.9012E+01 -1.5085E+01 -1.0815E+01 -5.7030E+01 2.1193E+10
XSBAR 0. 1.0469E+01 1.1586E+01 3.2053E+01 4.3526E+01 5.5738E+01 6.8965E+01 8.3562E+01 1.0000E+02
YSBAR -3.0171E+01 -2.9693E+01 -2.8504E+01 -2.6101E+01 -2.2658E+01 -1.7978E+01 -1.2889E+01 -6.7765E+02 2.5256E+10
ETAS 1.9765E+01 1.5361E+01 1.8381E+01 1.6456E+01 1.3810E+01 1.0416E+01 7.0453E+01 3.4337E+02 1.5773E+01
UETAD 1.9207E+01 1.3304E+01 1.5781E+01 1.2053E+01 2.1519E+01 2.2522E+01 2.2986E+01 2.3354E+01
XI 0. 1.7517E+02 1.7503E+01 2.6259E+01 3.5007E+01 4.3759E+01 5.2510E+01 6.1262E+01 7.0014E+01
CFSCCKC 7.6213E+02 7.7475E+02 8.4714E+02 1.0092E+01 1.2047E+01 1.3160E+01 1.4036E+01 1.5773E+01
CPBOUY 8.4544E+02 8.4202E+02 8.6680E+02 9.1306E+02 1.0280E+01 1.1661E+01 1.2656E+01 1.4019E+01 1.5773E+01

14 I= 1 X(1)= 0. X(1)= 0. Y(1)= -5.03459779E-02 ETAS(1)= 1.97653455E-01 ETASP(1)= 1.56992519E-15
I= 2 X(1)= 6.75173050E-02 X(1)= 8.78478420E-02 Y(1)= -4.97961126E-02 ETAS(1)= 1.93676327E-01 ETASP(1)= -7.77263118E-02
I= 3 X(1)= 1.75034610E-01 X(1)= 1.77029955E-01 Y(1)= -4.81121259E-02 ETAS(1)= 1.83810218E-01 ETASP(1)= -1.65092636E-01
I= 4 X(1)= 2.68551915E-01 X(1)= 2.68551915E-01 Y(1)= -4.51859587E-02 ETAS(1)= 1.64559197E-01 ETASP(1)= -2.62981758E-01
I= 5 X(1)= 3.50069220E-01 X(1)= 3.65224670E-01 Y(1)= -4.08357340E-02 ETAS(1)= 1.38079636E-01 ETASP(1)= -3.52127250E-01
I= 6 X(1)= 4.3756525E-01 X(1)= 4.67656101E-01 Y(1)= -3.47437101E-02 ETAS(1)= 1.04163747E-01 ETASP(1)= -3.91289616E-01
I= 7 X(1)= 5.25103830E-01 X(1)= 5.78684541E-01 Y(1)= -2.64457287E-02 ETAS(1)= 7.04533516E-02 ETASP(1)= -4.00407253E-01
I= 8 X(1)= 6.12621135E-01 X(1)= 7.01164750E-01 Y(1)= -1.52259632E-02 ETAS(1)= 3.43376557E-02 ETASP(1)= -4.02510975E-01
I= 9 X(1)= 7.00138440E-01 X(1)= 8.39055631E-01 Y(1)= 2.11926088E-10 ETAS(1)= 0. ETASP(1)= -3.86875467E-01

ZETA= 1.00000000E+00

15 I=1 I=2 I=3 I=4 I=5 I=6 I=7 I=8 I=9 I=10
P/RCVSQ 8.2750E+02 6.3633E+02 8.8000E+02 5.5104E+02 1.0488E+01 1.1044E+01 1.1482E+01 1.1945E+01 1.2351E+01
P/ROASTSQ 3.6238E+01 3.6238E+01 4.0229E+01 4.3476E+01 4.7944E+01 5.0489E+01 5.2490E+01 5.4607E+01 5.6461E+01
P/PTINF 1.2202E+02 1.2338E+02 1.2982E+02 1.4031E+02 1.5472E+02 1.6294E+02 1.6939E+02 1.7623E+02 1.8221E+02
P/PTINF 1.8536E+00 1.8734E+00 1.9712E+00 2.1303E+00 2.3493E+00 2.4738E+00 2.5720E+00 2.6157E+00 2.7666E+00
PHO 1.5434E+00 1.5544E+00 1.6052E+00 1.6951E+00 1.8080E+00 1.8697E+00 1.9169E+00 1.9658E+00 2.0076E+00
U 2.0191E+00 2.0138E+00 1.9966E+00 1.9693E+00 1.9300E+00 1.8783E+00 1.8101E+00 1.7279E+00 1.6316E+00
V -4.5573E-01 -4.4352E-01 -4.0378E-01 -3.3739E-01 -2.5274E-01 -1.7460E-01 -1.0684E-01 -4.4477E-02 9.3131E-11
W -3.8552E-16 -1.6208E-01 -3.1722E-01 -4.6056E-01 -5.9566E-01 -7.4248E-01 -8.9183E-01 -1.0337E-01 -1.1701E-01
UC 2.0692E+00 2.0676E+00 2.0588E+00 2.0468E+00 2.0285E+00 2.0178E+00 2.0095E+00 2.0006E+00 1.9929E+00
VC 5.3740E+02 5.1536E+02 5.1536E+02 5.1536E+02 5.1536E+02 5.1536E+02 5.1536E+02 5.1536E+02 5.1536E+02
MC -2.9335E+16 1.7428E+02 3.5665E+02 6.9258E+02 1.0237E+01 1.1931E+01 1.2757E+01 1.3605E+01 1.4044E+01
VCC 5.3740E+02 6.0059E+02 8.4926E+02 1.1972E+01 1.5674E+01 1.6730E+01 1.6748E+01 1.6712E+01 1.6334E+01
WCC -3.8552E-16 -2.6691E+03 -1.2785E+02 -3.3725E+02 -6.7733E+02 -1.0064E+01 -1.3056E+01 -1.5797E+01 -1.8172E+01
VX -3.8552E-16 1.8147E+02 4.1574E+02 7.3206E+02 1.0935E+01 1.2934E+01 1.4114E+01 1.5389E+01 1.6334E+01
VY -5.3740E+02 -3.7131E+02 -7.5153E+02 -1.0056E+01 -1.3115E+01 -1.4625E+01 -1.5868E+01 -1.7088E+01 -1.8172E+01
VZ 2.0692E+00 2.0676E+00 2.0588E+00 2.0468E+00 2.0285E+00 2.0178E+00 2.0095E+00 2.0006E+00 1.9929E+00
PSINCA -1.0675E+14 5.0206E+01 1.1563E+00 2.0484E+00 3.0856E+00 3.6076E+00 4.0075E+00 4.3986E+00 4.6857E+00
THEINCH 8.8512E+01 8.6412E+01 8.7911E+01 8.7185E+01 8.6306E+01 8.5863E+01 8.5497E+01 8.5132E+01 8.4807E+01
XBAR 0. 1.0469E+01 1.1586E+01 3.2053E+01 4.3526E+01 5.5738E+01 6.8965E+01 8.3562E+01 1.0000E+02
YBAR -3.0171E+01 -2.9693E+01 -2.8504E+01 -2.6101E+01 -2.2658E+01 -1.7978E+01 -1.2889E+01 -6.7765E+02 2.5256E+10
YBHL 0. 1.0469E+01 1.1586E+01 3.2053E+01 4.3526E+01 5.5738E+01 6.8965E+01 8.3562E+01 1.0000E+02
ETA 1.9765E+01 1.5361E+01 1.8381E+01 1.6456E+01 1.3810E+01 1.0416E+01 7.0453E+01 3.4337E+02 1.5773E+01
G -4.5946E-01 -4.6013E-01 -4.6130E-01 -4.6236E-01 -4.6279E-01 -4.6305E-01 -4.6311E-01 -4.6307E-01 -4.6307E-01
DECNS 1.8353E+00 1.6710E+00 2.0236E+00 2.2746E+00 2.5933E+00 2.7597E+00 2.8409E+00 2.8921E+00 2.9292E+00
AP 3.5336E+00 3.5252E+00 3.4647E+00 3.4220E+00 3.3409E+00 3.2971E+00 3.2637E+00 3.2292E+00 3.1998E+00
CROSSM 7.7800E+01 8.0476E+01 8.6796E+01 9.5335E+01 1.0620E+02 1.2405E+02 1.4507E+02 1.6585E+02 1.8647E+02
SEAR 5.5057E+03 1.0001E+02 1.2165E+02 1.7412E+02 2.4982E+02 3.7930E+02 5.7993E+02 8.7993E+02 1.2000E+03
PORDGAM 4.5009E+02 4.5009E+02 4.5210E+02 4.5210E+02 4.5210E+02 4.5210E+02 4.5210E+02 4.5210E+02 4.5210E+02
PT/PTINF 9.7692E+01 9.7511E+01 9.6855E+01 9.5740E+01 9.3946E+01 9.2837E+01 9.1929E+01 9.0939E+01 9.0050E+01
PT 6.1262E+00 6.1101E+00 6.0679E+00 6.0486E+00 6.0380E+00 6.0298E+00 6.0231E+00 6.0164E+00 6.0103E+00
BEPNCLL 3.5527E+14 3.5527E+14 3.5527E+14 3.5527E+14 3.5527E+14 3.5527E+14 3.5527E+14 3.5527E+14 3.5527E+14
DPDZ -1.5044E+02 -1.1350E+02 5.7038E+04 1.4703E+02 1.7373E+02 1.1109E+02 9.5010E+03 5.5813E+03 1.1111
DUDZ -5.0007E+02 -6.5911E+02 -7.4178E+02 -5.5363E+02 -3.4728E+02 -1.8367E+02 -7.4376E+03 -1.8593E+03 1.1111
DWDZ -4.9685E+01 -4.7206E+01 -3.4619E+01 -2.9846E+01 -2.2335E+01 -1.6339E+01 -9.7288E+02 -4.2071E+02 1.1111
DWDZ 1.7375E+15 1.4547E+02 3.4542E+02 5.1185E+02 3.4480E+02 2.1699E+02 1.8557E+02 8.9573E+03 1.1111
DSBZ -8.7335E+32 -1.1352E+03 -5.2365E+03 -1.2361E+02 -1.3225E+02 -1.6947E+01 -6.3215E+03 -3.6329E+03 1.1111
UP 1.2702E+01 2.5671E+02 6.4313E+02 1.0304E+01 9.1312E+02 5.2559E+02 5.0801E+02 4.9672E+02 1.1111
VP -5.5000E+15 -1.2385E+01 -2.5619E+01 -3.7787E+01 -5.1604E+01 -6.8378E+01 -8.6120E+01 -1.0156E+01 1.1111
WP -4.8214E+15 2.9465E+01 6.1510E+01 8.9450E+01 9.5734E+01 8.3252E+01 7.5052E+01 6.1034E+01 1.1111
SBARP -1.8652E+00 -1.8231E+00 -1.7058E+00 -1.5684E+00 -1.5971E+00 -1.7111E+00 -1.6858E+00 -1.5897E+00 1.1111
5.2676E+16 1.6635E+02 4.1716E+02 7.5405E+02 7.3794E+02 4.6526E+02 4.6814E+02 4.1717E+02 1.1111

16 XBSNCA= 2.81723225E+01 YBSNCA= -2.46223328E+01

APPENDIX C

ZETA= 9.0000000E-01										
	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
P/RCVSQ	8.3951E-02	8.4566E-02	8.8017E-02	9.3862E-02	1.0326E-01	1.0937E-01	1.1388E-01	1.1890E-01	1.2351E-01	
P/RCASTSQ	3.8378E-01	3.8659E-01	4.0236E-01	4.2908E-01	4.7203E-01	5.0300E-01	5.4058E-01	5.8361E-01	5.4661E-01	
P/PTINF	1.2350E-02	1.2476E-02	1.2958E-02	1.3847E-02	1.5233E-02	1.6136E-02	1.6800E-02	1.7542E-02	1.8221E-02	
P/PINF	1.8805E+00	1.8543E+00	1.5716E+00	2.1025E+00	2.3129E+00	2.4500E+00	2.5508E+00	2.6634E+00	2.7666E+00	
R-0	1.5554E+00	1.5669E+00	1.6087E+00	1.6777E+00	1.7863E+00	1.8557E+00	1.9048E+00	1.9588E+00	2.0076E+00	
U	2.0276E+00	2.0220E+00	2.0036E+00	1.9746E+00	1.9335E+00	1.8800E+00	1.8108E+00	1.7281E+00	1.6316E+00	
V	-4.0755E-01	-3.5731E-01	-3.3633E-01	-3.0680E-01	-2.2998E-01	-1.5812E-01	-9.6966E-02	-4.0243E-02	9.3131E-01	
W	-7.4160E-16	-1.6328E-01	-3.2200E-01	-4.4551E-01	-5.9939E-01	-7.4461E-01	-8.9360E-01	-1.0342E-01	-1.1701E-01	
UC	2.0672E+00	2.0660E+00	2.0555E+00	2.0482E+00	2.0304E+00	2.0192E+00	2.0108E+00	2.0014E+00	1.9929E+00	
VC	6.1689E-02	6.4473E-02	7.9457E-02	1.0172E-01	1.3288E-01	1.5154E-01	1.6697E-01	1.8376E-01	1.9995E-01	
WC	-6.3575E-16	1.6114E-02	3.6764E-02	6.5088E-02	9.9033E-02	1.1751E-01	1.2613E-01	1.3538E-01	1.4044E-01	
VCC	6.1689E-02	6.5571E-02	8.5152E-02	1.1403E-01	1.4580E-01	1.6235E-01	1.6364E-01	1.6525E-01	1.6334E-01	
WCC	-7.4160E-16	-8.0181E-02	-2.0504E-02	-3.9759E-02	-7.0880E-02	-1.0207E-01	-1.3042E-01	-1.5744E-01	-1.8172E-01	
VX	-7.4160E-16	1.6920E-02	3.8758E-02	6.8939E-02	1.0581E-01	1.2735E-01	1.3947E-01	1.5306E-01	1.6334E-01	
VY	-6.1689E-02	-6.2666E-02	-7.8544E-02	-9.9155E-02	-1.2754E-01	-1.4338E-01	-1.5600E-01	-1.6931E-01	-1.8172E-01	
VZ	2.0672E+00	2.0660E+00	2.0555E+00	2.0482E+00	2.0304E+00	2.0192E+00	2.0108E+00	2.0014E+00	1.9929E+00	
PSINOR	-2.0554E-14	4.6922E-01	1.0781E+00	1.5277E+00	2.9833E+00	3.6089E+00	3.9678E+00	4.3733E+00	4.6857E+00	
TJETNOR	8.8291E+01	8.8218E+01	8.7810E+01	8.7230E+01	8.6410E+01	8.5947E+01	8.5574E+01	8.5178E+01	8.4807E+01	
XBAR	0.	1.0830E-01	2.1801E-01	3.3042E-01	4.4705E-01	5.6949E-01	7.0064E-01	8.4280E-01	1.0000E+00	
XBLD	0.	6.5457E-02	1.9633E-01	3.0305E-01	4.2649E-01	5.4691E-01	6.7819E-01	8.2989E-01	1.0000E+00	
YEAR	-2.7677E-01	-2.7244E-01	-2.6162E-01	-2.3975E-01	-2.0845E-01	-1.6576E-01	-1.1907E-01	-6.2964E-02	2.5256E-10	
YBLD	-2.7677E-01	-2.7335E-01	-2.6375E-01	-2.4510E-01	-2.1397E-01	-1.7363E-01	-1.2706E-01	-6.8000E-02	2.5256E-10	
ETA	1.7789E-01	1.7431E-01	1.6543E-01	1.4810E-01	1.2429E-01	9.3747E-02	6.3408E-02	3.0904E-02	0.	
G	-4.1140E-01	-4.1264E-01	-4.1515E-01	-4.2055E-01	-4.2955E-01	-4.4224E-01	-4.5913E-01	-4.8159E-01	-5.0914E-01	
DEQNS	2.4125E+00	2.4308E+00	2.5225E+00	2.6833E+00	2.9436E+00	3.0993E+00	3.1648E+00	3.2114E+00	3.2414E+00	
AM	3.5234E+00	3.5171E+00	3.4635E+00	3.4285E+00	3.3493E+00	3.3025E+00	3.2682E+00	3.2318E+00	3.1998E+00	
CROSSM	6.9432E+01	7.3687E-01	8.1663E-01	9.3139E-01	1.0555E+00	1.2394E+00	1.4531E+00	1.6605E+00	1.8647E+00	
SBAR	9.5057E-03	1.0134E-02	1.3228E-02	1.8759E-02	2.6313E-02	3.0503E-02	3.4315E-02	3.8361E-02	4.1920E-02	
PCROGAM	4.5069E-02	4.5098E-02	4.5237E-02	4.5488E-02	4.5833E-02	4.6026E-02	4.6201E-02	4.6389E-02	4.6595E-02	
PT/PTINF	9.7652E-01	5.7458E-01	5.6747E-01	5.5419E-01	5.3533E-01	5.2658E-01	5.1779E-01	5.0855E-01	5.0050E-01	
PT	6.6152E+00	6.6088E+00	6.5579E+00	6.4678E+00	6.3488E+00	6.2807E+00	6.2211E+00	6.1585E+00	6.1039E+00	
BERNDUL	-1.1420E-09	-1.8991E-06	-5.3406E-06	-1.9210E-05	-4.3797E-05	-4.4323E-05	-1.2853E-05	-3.5996E-06	4.2633E-14	
DPDZ	-8.6493E-03	-7.6692E-03	-6.5311E-03	-5.0407E-03	-1.5070E-02	-1.0286E-02	-9.0224E-03	-5.3935E-03	0.	
DUDZ	-8.0554E-02	-7.6919E-02	-6.6639E-02	-5.0149E-02	-3.1294E-02	-1.6521E-02	-6.7152E-03	-1.6967E-03	0.	
DVDZ	-4.7017E-01	-4.5416E-01	-4.0378E-01	-3.1623E-01	-2.3175E-01	-1.6612E-01	-1.0005E-01	-4.2610E-02	0.	
DMOZ	-7.6472E-17	1.0020E-02	2.6237E-02	3.7679E-02	3.4582E-02	2.0787E-02	1.6837E-02	8.5712E-03	0.	
DSBDZ	-1.6592E-32	-1.5437E-02	-7.0420E-03	-1.4621E-02	-1.3576E-02	-7.7633E-03	-6.7426E-03	-3.7164E-03	0.	
PP	-7.6832E-17	2.1210E-02	5.2435E-02	9.2461E-02	9.3543E-02	5.7055E-02	5.3301E-02	5.5026E-02	5.5026E-02	
UP	3.4992E-14	-1.3749E-01	-2.7093E-01	-4.0027E-01	-5.3700E-01	-6.9886E-01	-8.6999E-01	-1.0236E+00	0.	
VP	-7.3634E-16	2.4821E-01	5.2188E-01	7.9032E-01	8.7715E-01	7.5964E-01	6.7893E-01	5.5398E-01	0.	
WP	-1.8781E+00	-1.8356E+00	-1.7308E+00	-1.5743E+00	-1.5806E+00	-1.6955E+00	-1.6625E+00	-1.5756E+00	0.	
SBARP	4.6588E-17	2.0143E-02	4.5454E-02	8.0282E-02	6.9385E-02	4.2286E-02	4.4996E-02	4.3450E-02	0.	
XBSNIC= 3.5468E104E-01 YBSNIC= -2.22465212E-01										

ZETA= 8.0000000E-01										
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P/RCVSQ	8.4761E-02	8.5216E-C2	8.8100E-02	9.2975E-02	1.0186E-01	1.0839E-01	1.1301E-01	1.1837E-01	1.2351E-01	
P/RCASTSQ	3.8748E-01	3.8956E-C1	4.0274E-C1	4.2503E-01	4.6564E-01	4.9548E-01	5.1662E-01	5.4135E-01	5.6461E-01	
P/PTINF	1.2505E-02	1.2572E-C2	1.2597E-C2	1.3717E-02	1.5027E-02	1.5990E-02	1.6722E-02	1.7463E-02	1.8221E-02	
P/PINF	1.8986E+00	1.8588E+00	1.5734E+00	2.0327E+00	2.2817E+00	2.4278E+00	2.5315E+00	2.6516E+00	2.7666E+00	
R-0	1.5701E+00	1.5752E+00	1.6088E+00	1.6645E+00	1.7673E+00	1.8427E+00	1.8935E+00	1.9520E+00	2.0076E+00	
U	2.0352E+00	2.0292E+00	2.0099E+00	1.9794E+00	1.9363E+00	1.8816E+00	1.8114E+00	1.7283E+00	1.6316E+00	
V	-3.6126E-01	-3.5241E-01	-3.3214E-01	-2.7433E-C1	-2.0642E-01	-1.4138E-C1	-8.6861E-02	-3.5955E-02	9.3131E-11	
W	-5.3143E-16	-1.6413E-C1	-3.2186E-01	-4.6861E-01	-6.0266E-01	-7.4666E-C1	-8.9520E-01	-1.0350E+00	-1.1701E+00	
UC	2.0659E+00	2.0649E+00	2.0590E+00	2.0490E+00	2.0320E+00	2.0205E+00	2.0119E+00	2.0020E+00	1.9929E+00	
VC	6.7680E-02	7.0009E-02	8.3028E-02	1.0150E-01	1.2983E-01	1.4878E-C1	1.6441E-01	1.8216E-01	1.9995E-01	
WCC	-8.1535E-16	1.5184E-02	3.4887E-C2	6.2000E-02	9.6067E-02	1.1578E-01	1.2481E-01	1.3473E-01	1.4044E-01	
VCC	6.7680E-02	7.0427E-02	8.5602E-02	1.0965E-01	1.4341E-01	1.5751E-01	1.5999E-01	1.6343E-01	1.6334E-01	
WCC	-9.3143E-16	-1.3108E-C2	-2.7564E-C2	-4.6077E-02	-7.4287E-02	-1.0359E-C1	-1.3042E-01	-1.5694E-01	-1.8172E-01	
VX	-9.3143E-16	1.6059E-02	3.6571E-C2	6.5845E-02	1.0269E-01	1.2543E-01	1.3794E-01	1.5226E-01	1.6334E-01	
VY	-6.7680E-02	-6.5813E-C2	-8.2122E-02	-9.9047E-C2	-1.2465E-01	-1.4074E-C1	-1.5356E-01	-1.6779E-01	-1.8172E-01	
VZ	2.0655E+00	2.0645E+00	2.0590E+00	2.0490E+00	2.0320E+00	2.0205E+00	2.0119E+00	2.0020E+00	1.9929E+00	
PSINOR	-2.5832E-14	4.4559E-01	1.0286E+00	1.8405E+00	2.8932E+00	3.5525E+00	3.9223E+00	4.3491E+00	4.6857E+00	
TJETNCR	8.8124E+01	8.8064E+01	8.7716E+01	8.7234E+01	8.6494E+01	8.6023E+01	8.5646E+01	8.5233E+01	8.4807E+01	
W0Z	0.	1.0769E-01	2.1721E-01	3.2930E-01	4.4572E-01	5.6813E-C1	6.9941E-01	8.4200E-01	1.0000E+00	
XBLD0	0.	6.5887E-02	1.7528E-01	2.7708E-01	4.0278E-01	5.1519E-01	6.5181E-01	8.1353E-01	1.0000E+00	
YEAR	-2.5205E-01	-2.4816E-01	-2.3638E-C1	-2.1871E-C1	-1.9041E-01	-1.5179E-C1	-1.0928E-01	-5.7968E-02	2.5256E-10	
YBLD0	-2.5205E-01	-2.4967E-01	-2.4213E-C1	-2.2788E-01	-2.0085E-01	-1.6849E-01	-1.2469E-01	-6.8213E-02	2.5256E-10	
ETA	1.5812E-01	1.5494E-01	1.4765E-01	1.3165E-01	1.1048E-01	8.3331E-02	5.6363E-02	2.7470E-02	0.	
G	-3.6486E-01	-3.6623E-C1	-3.6923E-C1	-3.7624E-01	-3.7883E-01	-3.7685E-C1	-3.7453E-01	-3.6948E-01	-3.6488E-01	
DEQNS	2.9015E+00	2.9124E+00	2.9746E+00	3.0748E+00	3.2735E+00	3.4089E+00	3.4601E+00	3.4987E+00	3.5247E+00	
AM	3.5166E+00	3.5114E+00	3.4815E+00	3.4328E+00	3.3562E+00	3.3074E+00	3.2723E+00	3.2342E+00	3.1998E+00	
CROSSM	6.1462E+01	6.6070E-01	7.7042E-01	9.0816E-01	1.0489E+00	1.2385E+00	1.4552E+00	1.6624E+00	1.8647E+00	
SBAR	9.5057E-03	1.0318E-C2	1.4047E-C2	2.0347E-C2	2.7650E-02	3.1285E-C2	3.5015E-02	3.8736E-02	4.1920E-02	
PCROGAM	4.5069E-02	4.5106E-C2	4.5274E-C2	4.5561E-02	4.5896E-02	4.6062E-C2	4.6234E-02	4.6406E-02	4.6595E-02	
PT/PTINF	9.7652E-01	5.7454E-01	5.6549E-01	5.5040E-01	5.3312E-01	5.2477E-01	5.1619E-01	5.0770E-01	5.0050E-01	
PT	6.6152E+00	6.6058E+00	6.5445E+00	6.4422E+00	6.3205E+00	6.2684E+00	6.2102E+00	6.1527E+00	6.1039E+00	
BERNDUL	-1.3543E-09	-3.8317E-C6	-1.3106E-05	-3.9016E-05	-9.4715E-05	-1.1469E-05	-3.0376E-05	-4.7217E-06	4.2633E-14	
DPDZ	-6.7852E-03	-5.0711E-03	-4.0251E-03	-2.5203E-03	-1.2857E-02	-9.5045E-03	-8.2933E-03	-5.2052E-03	0.	
DUDZ	-7.1405E-02	-6.6149E-02	-5.8920E-02	-4.4357E-02	-2.7724E-02	-1.4658E-02	-5.9740E-03	-1.5319E-03	0.	
DVDZ	-4.5695E-01	-4.4413E-01	-4.0565E-01	-3.2830E-01	-2.3941E-01	-1.6870E-C1	-1.0235E-01	-4.3153E-02	0.	
DMOZ	1.1330E-15	7.1891E-03	1.3782E-02	2.6222E-02	3.0373E-02	1.9839E-02	1.5323E-02	8.1696E-03	0.	
DSBDZ	5.7268E-32	-2.1737E-02	-9.4676E-03	-1.7205E-02	-1.3918E-02	-7.9009E-03	-7.2764E-03	-3.7948E-03	0.	
PP	7.3085E-16	1.8046E-02	4.2826E-02	8.2756E-02	9.3663E-02	6.0767E-C2	5.5471E-02	5.9966E-02	0.	
UP	7.2424E-16	-1.4511E-01	-2.5572E-01	-4.2020E-01	-5.5578E-01	-7.1198E-01	-8.7782E-01	-1.0273E+00	0.	
VP	3.4618E-15	2.1603E-C1	4.4730E-01	6.8823E-01	7.6781E-01	6.3388E-01	6.0650E-01	4.9615E-01	0.	
WP	-1.8877E+00	-1.6493E+00	-1.7455E+00	-1.5843E+00	-1.5720E+00	-1.6891E+00	-1.6565E+00	-1.5704E+00	0.	
SBARP	-1.1350E-16	-2.5043E-02	5.5648E-02	8.3962E-02	6.3354E-02	3.8284E-02	4.3209E-02	3.9452E-02	0.	
XBSCNIC= 4.05287673E-C1 YBSCNIC= -2.02241767E-01										

APPENDIX C

	ZETA= 7.0000000E-01									
	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
P/FCV3Q	8.5334E-02	6.5691E-02	6.8187E-02	9.2326E-02	1.0057E-01	1.0747E-01	1.1221E-01	1.1786E-01	1.2351E-01	
P/ROASTSQ	3.9014E-01	3.5173E-01	4.0314E-01	4.2204E-01	4.6020E-01	4.9130E-01	5.1298E-01	5.3880E-01	5.6461E-01	
P/PTINF	1.2591E-02	1.2642E-02	1.3010E-02	1.3621E-02	1.4851E-02	1.5855E-02	1.7388E-02	1.8221E-02	1.8221E-02	
P/PINF	1.9117E+00	1.5155E+00	1.5194E+00	2.0081E+00	2.2550E+00	2.4074E+00	2.5136E+00	2.6401E+00	2.7666E+00	
AMU	1.5778E+00	1.5812E+00	1.6087E+00	1.6539E+00	1.7507E+00	1.8305E+00	1.8829E+00	1.9455E+00	2.0076E+00	
U	2.0415E+00	2.0356E+00	2.0154E+00	1.9835E+00	1.9389E+00	1.8830E+00	1.8120E+00	1.7284E+00	1.6316E+00	
V	-3.1558E-01	-3.0822E-01	-2.8253E-01	-2.4107E-01	-1.8214E-01	-1.2438E-01	-7.6507E-02	-3.1613E-02	9.3131E-11	
W	-9.7704E-10	-1.6474E-01	-3.2286E-01	-4.7378E-01	-6.0548E-01	-7.4857E-01	-8.9666E-01	-1.0358E+00	-1.1701E+00	
UC	2.0644E+00	2.0646E+00	2.0585E+00	2.0494E+00	2.0332E+00	2.0216E+00	2.0129E+00	2.0027E+00	1.9929E+00	
VC	7.2572E-02	7.4741E-02	8.6570E-02	1.0215E-01	1.2742E-01	1.4625E-01	1.6205E-01	1.8062E-01	1.9955E-01	
WC	-8.5337E-10	1.4522E-02	3.3801E-02	5.9485E-02	9.3467E-02	1.1410E-01	1.2360E-01	1.3412E-01	1.4044E-01	
VCC	7.2572E-02	7.3905E-02	8.9454E-02	1.0608E-01	1.3748E-01	1.5279E-01	1.5652E-01	1.6165E-01	1.6334E-01	
VCC	-9.7704E-10	-1.8308E-02	-3.5377E-02	-5.2516E-02	-7.7925E-02	-1.0519E-01	-1.3053E-01	-1.5647E-01	-1.8172E-01	
VX	-9.7704E-10	1.5450E-02	3.5574E-02	6.3720E-02	9.5572E-02	1.2360E-01	1.3654E-01	1.5149E-01	1.6334E-01	
VY	-7.2572E-02	7.4554E-02	8.5656E-02	9.9784E-02	1.2239E-01	1.3832E-01	1.5131E-01	1.6632E-01	1.8172E-01	
VZ	2.0644E+00	2.0640E+00	2.0585E+00	2.0494E+00	2.0332E+00	2.0216E+00	2.0129E+00	2.0027E+00	1.9929E+00	
PSINCR	-2.7132E-14	4.2605E-01	1.0012E+00	1.7809E+00	2.8149E+00	3.4986E+00	3.8806E+00	4.3259E+00	4.8875E+00	
THEINCR	8.7367E+01	8.7931E+01	8.7616E+01	8.7214E+01	8.6560E+01	8.6093E+01	8.5711E+01	8.5266E+01	8.4807E+01	
ABAR	U	1.0748E-01	2.1642E-01	3.2614E-01	4.4439E-01	5.6678E-01	6.9819E-01	8.4120E-01	1.0000E+00	
ABFLD	U	4.5545E-02	1.5587E-01	2.5220E-01	3.7033E-01	4.7064E-01	6.2287E-01	7.9305E-01	1.0000E+00	
YEAR	-2.2754E-01	-2.2408E-01	-2.1532E-01	-1.9777E-01	-1.7247E-01	-1.3786E-01	-9.9498E-02	-5.2976E-02	2.5256E-10	
YBHL	-2.2754E-01	-2.2555E-01	-2.2018E-01	-2.0910E-01	-1.8757E-01	-1.6504E-01	-1.2149E-01	-8.6638E-02	2.5256E-10	
ETA	1.3830E-01	1.3557E-01	1.2676E-01	1.1519E-01	9.6609E-02	7.2915E-02	4.9317E-02	2.4036E-02	0.	
G	-3.1917E-01	-3.2036E-01	-3.2291E-01	-3.3052E-01	-3.3355E-01	-3.3082E-01	-3.2856E-01	-3.2365E-01	1.1111	
CEGNS	3.1819E+00	3.3270E+00	3.3737E+00	3.4345E+00	3.4764E+00	3.4863E+00	3.4733E+00	3.4353E+00	3.3753E+00	
AP	3.5118E+00	3.5070E+00	3.4788E+00	3.4344E+00	3.3618E+00	3.3119E+00	3.2759E+00	3.2365E+00	3.1998E+00	
CROSSP	9.5057E-03	9.5057E-03	1.0581E-02	1.5153E-02	2.2100E-02	3.4080E-02	3.2089E-02	3.5775E-02	1.8647E+00	
SBAR	9.5057E-03	9.5057E-03	1.0581E-02	1.5153E-02	2.2100E-02	3.4080E-02	3.2089E-02	3.5775E-02	1.8647E+00	
PCRCGAM	4.5069E-02	4.5118E-02	4.5325E-02	4.5645E-02	4.5960E-02	4.6099E-02	4.6269E-02	4.6464E-02	4.6554E-02	
PT/PTINF	9.7652E-01	9.7309E-01	9.6283E-01	9.4555E-01	9.2986E-01	9.2291E-01	9.1445E-01	9.0683E-01	9.0050E-01	
PI	6.6152E+00	6.6014E+00	6.5264E+00	6.4123E+00	6.3030E+00	6.2558E+00	6.1984E+00	6.1468E+00	6.1039E+00	
BERNCUL	-1.4202E-09	-6.6567E-06	-2.2639E-05	-5.6149E-05	1.5133E-04	-2.3889E-05	-5.1863E-05	-2.8374E-06	4.2633E-14	
DPDZ	-4.9954E-03	-4.0863E-03	-8.0390E-04	5.5984E-03	1.0973E-02	8.7475E-03	7.6777E-03	5.0224E-03	1.1111	
DUDZ	-6.2454E-02	-5.5454E-02	-5.0582E-02	-3.8244E-02	-2.4350E-02	-1.2785E-02	-5.2107E-03	-1.2652E-03	1.1111	
DVDZ	-4.9954E-03	-4.3861E-03	-4.0863E-03	-3.3631E-03	-2.4593E-03	-1.7116E-03	-1.0433E-03	-4.3680E-04	1.1111	
DNBZ	-4.2642E-15	4.6502E-03	6.4235E-03	1.7328E-02	2.6232E-02	1.8754E-02	1.3894E-02	7.7658E-03	1.1111	
CSBZ	-2.8667E-31	-3.1819E-02	-1.2653E-02	-2.0077E-02	-1.3943E-02	-8.2133E-03	-7.9473E-03	-3.8584E-03	1.1111	
PP	2.4051E-15	1.5340E-02	3.5474E-02	7.4341E-02	4.5202E-02	6.3633E-02	5.7392E-02	6.4524E-02	1.1111	
UP	6.8620E-15	-1.5208E-01	-2.5689E-01	-4.3755E-01	-5.7215E-01	-7.2364E-01	-8.8471E-01	-1.0305E+00	1.1111	
VP	-1.1064E-14	1.6085E-01	3.8403E-01	5.8965E-01	6.9273E-01	6.0921E-01	5.3324E-01	4.7101E-01	1.1111	
WP	-1.8949E-01	-1.8543E+00	-1.7548E+00	-1.5970E+00	-1.5697E+00	-1.6801E+00	-1.6506E+00	-1.5620E+00	1.1111	
SBARP	4.7341E-10	3.1949E-02	6.9537E-02	8.5055E-02	5.5619E-02	3.4846E-02	4.1333E-02	3.5110E-02	1.1111	
ABSCNIC=	4.1317055E-01 YBSCNIC= -1.7526465E-01									

	ZETA= 6.0000000E-01									
	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
P/ROVSQ	8.5778E-02	8.6647E-02	8.8256E-02	9.1835E-02	9.4650E-02	1.0663E-01	1.1147E-01	1.1737E-01	1.2351E-01	
P/ROASTSQ	3.9213E-01	3.9336E-01	4.0384E-01	4.1982E-01	4.5557E-01	4.8747E-01	5.0559E-01	5.3654E-01	5.6461E-01	
P/PTINF	1.2659E-02	1.2654E-02	1.3020E-02	1.3548E-02	1.4702E-02	1.5732E-02	1.6445E-02	1.7315E-02	1.8221E-02	
P/PINF	1.9214E+00	1.5275E+00	1.5769E+00	2.0571E+00	2.2323E+00	2.3880E+00	2.4970E+00	2.6291E+00	2.7666E+00	
RHC	1.5036E+00	1.5655E+00	1.6079E+00	1.6451E+00	1.7364E+00	1.8192E+00	1.8729E+00	1.9391E+00	2.0076E+00	
U	2.0477E+00	2.0411E+00	2.0202E+00	1.9870E+00	1.9411E+00	1.8842E+00	1.8125E+00	1.7285E+00	1.6316E+00	
V	-2.7129E-01	-2.6440E-01	-2.4164E-01	-2.0717E-01	-1.5727E-01	-1.0715E-01	-6.5586E-02	-2.7219E-02	9.3131E-11	
W	-1.3641E-15	-1.6511E-01	-3.2315E-01	-4.7213E-01	-6.0793E-01	-7.5038E-01	-8.9798E-01	-1.0366E+00	-1.1701E+00	
UC	2.0642E+00	2.0632E+00	2.0578E+00	2.0494E+00	2.0342E+00	2.0227E+00	2.0138E+00	2.0033E+00	1.9929E+00	
VC	7.6779E-02	7.9007E-02	9.0106E-02	1.0337E-01	1.2555E-01	1.4393E-01	1.5987E-01	1.7913E-01	1.9955E-01	
VCC	7.6779E-02	7.6622E-02	8.6035E-02	1.0296E-01	1.3189E-01	1.4819E-01	1.5321E-01	1.5952E-01	1.6334E-01	
WCC	-1.3841E-15	-2.3675E-02	-4.2823E-02	-5.5190E-02	-8.1752E-02	-1.0685E-01	-1.3073E-01	-1.5603E-01	-1.8172E-01	
VX	-1.3841E-15	1.5090E-02	3.5680E-02	6.2391E-02	9.7592E-02	1.2186E-01	1.3526E-01	1.5076E-01	1.6334E-01	
VY	-7.6779E-02	7.8825E-02	8.9234E-02	1.0105E-01	1.2064E-01	1.3611E-01	1.4922E-01	1.6489E-01	1.8172E-01	
VZ	2.0642E+00	2.0631E+00	2.0578E+00	2.0494E+00	2.0342E+00	2.0227E+00	2.0138E+00	2.0033E+00	1.9929E+00	
PSINCR	-3.8419E-14	4.1504E-01	9.9336E-01	1.7438E+00	2.7466E+00	3.4478E+00	3.8427E+00	4.3038E+00	4.8875E+00	
THEINCR	8.7870E+01	8.7312E+01	8.7517E+01	8.7178E+01	8.6610E+01	8.6157E+01	8.5772E+01	8.5303E+01	8.4807E+01	
ABAR	U	1.0768E-01	2.1503E-01	3.2708E-01	4.4304E-01	5.6542E-01	6.9696E-01	8.4004E-01	1.0000E+00	
ABFLD	U	3.6104E-02	1.3635E-01	2.2646E-01	3.3878E-01	4.2912E-01	5.9130E-01	7.6547E-01	1.0000E+00	
YEAR	-2.0322E-01	-2.0377E-01	-1.9242E-01	-1.7695E-01	-1.5460E-01	-1.2398E-01	-8.7397E-02	-4.7989E-02	2.5256E-10	
YBHL	-2.0322E-01	-2.0219E-01	-1.9753E-01	-1.9052E-01	-1.7469E-01	-1.5729E-01	-1.1724E-01	-6.9797E-02	2.5256E-10	
ETA	1.1859E-01	1.1621E-01	1.1029E-01	9.8736E-02	8.2859E-02	6.2498E-02	4.2272E-02	2.0603E-02	0.	1111
G	-2.7355E-01	-2.7474E-01	-2.7635E-01	-2.8388E-01	-2.8740E-01	-2.8438E-01	-2.8227E-01	-2.7770E-01	1.1111	1111
CEGNS	3.6721E+00	3.6755E+00	3.7175E+00	3.7524E+00	3.8463E+00	3.9244E+00	3.9555E+00	3.9746E+00	3.9746E+00	1111
AM	3.5062E+00	3.5034E+00	3.4757E+00	3.4344E+00	3.3636E+00	3.3158E+00	3.2791E+00	3.2387E+00	3.1998E+00	
CROSSP	4.0007E-01	5.2891E-01	6.3059E-01	8.0255E-01	1.0361E+00	1.2376E+00	1.4589E+00	1.6660E+00	1.8647E+00	
SBAR	9.5057E-03	1.0581E-02	1.6664E-02	2.3666E-02	3.0444E-02	3.2940E-02	3.6609E-02	3.9070E-02	4.1920E-02	
PCRCGAM	4.5069E-02	4.5136E-02	4.5353E-02	4.5744E-02	4.6024E-02	4.6138E-02	4.6307E-02	4.6442E-02	4.6554E-02	
PT/PTINF	9.7652E-01	9.7293E-01	9.5920E-01	9.4090E-01	9.2667E-01	9.2095E-01	9.1254E-01	9.0595E-01	9.0050E-01	
PI	6.6152E+00	6.5549E+00	6.5018E+00	6.3778E+00	6.2813E+00	6.2425E+00	6.1855E+00	6.1409E+00	6.1039E+00	
BERNCUL	-1.4580E-09	-1.2439E-05	-3.2344E-05	-6.6277E-05	2.1038E-04	-4.5380E-05	-7.1444E-06	2.7144E-06	4.2633E-14	
DPDZ	-3.7718E-03	-3.0733E-03	-5.7348E-04	4.3093E-03	9.3207E-03	8.0203E-03	7.1446E-03	4.8482E-03	1.1111	
DUDZ	-5.3621E-02	-5.0714E-02	-4.2788E-02	-3.1965E-02	-2.0354E-02	-1.0898E-02	-4.4176E-03	-1.1978E-03	1.1111	
DVDZ	-4.4487E-01	-4.3310E-01	-4.0729E-01	-3.4144E-01	-2.5125E-01	-1.7552E-01	-1.0607E-01	-4.4182E-02	1.1111	
DNBZ	-5.0018E-16	2.4479E-03	3.2481E-04	9.8311E-03	2.2889E-02	1.7419E-02	1.2462E-02	7.3728E-03	1.1111	
OSBZ	-2.0667E-31	-4.8626E-02	-1.7339E-02	-1.3531E-02	-8.9030E-03	-8.7664E-03	-3.8891E-03	1.1111	1.1111	
PP	-1.8068E-16	1.3364E-02	3.6676E-02	6.7235E-02	9.5081E-02	9.5706E-02	9.5053E-02	8.6754E-02	1.1111	
VP	6.5322E-15	1.3064E-01	3.1086E+00	6.2718E+00	1.0960E+01	1.4940E+01	1.9404E+01	2.4404E+01	3.0004E+01	1.1111
WP	-1.4060E-13	1.4940E-01	2.7472E-01	4.9448E-01	7.9461E-01	5.2022E-01	4.5910E-01	3.7696E-01	1.1111	
WP	-1.4060E+00	1.4546E+00	1.7549E+00	-1.6120E+00	-1.5723E+00	-1.6720E+00	-1.6449E+00	-1.5545E+00	1.1111	
SBARP	2.0663E-16	4.1777E-02	8.2546E-02	8.4210E-02	4.6321E-02	3.2192E-02	3.9113E-02	3.0342E-02	1.1111	
ABSCNIC=	4.18934000E-01	YESNIC(=	-1.55249162E-01							

APPENDIX C

	ZETA= 5.00C00000E-01									
	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
P/RCVSQ	8.6109E-02	8.6314E-02	8.8300E-02	9.1451E-02	9.8796E-02	1.0587E-01	1.1078E-01	1.1689E-01	1.2351E-01	
P/ROASTSQ	3.9364E-01	3.9458E-01	4.0366E-01	4.1806E-01	4.5164E-01	4.8397E-01	5.0644E-01	5.3436E-01	5.6461E-01	
P/PTINF	1.2734E-02	1.2734E-02	1.3027E-02	1.3492E-02	1.4575E-02	1.5618E-02	1.6344E-02	1.7214E-02	1.8221E-02	
P/PTINF	1.9288E+00	1.9334E+00	1.9779E+00	2.0485E+00	2.2130E+00	2.3714E+00	2.4815E+00	2.6184E+00	2.7666E+00	
RHO	1.5879E+00	1.5833E+00	1.6061E+00	1.6373E+00	1.7241E+00	1.8086E+00	1.8634E+00	1.9329E+00	2.0076E+00	
U	2.0526E+00	2.0457E+00	2.0239E+00	1.9859E+00	1.9430E+00	1.8851E+00	1.8129E+00	1.7287E+00	1.6316E+00	
V	-2.2694E-01	-2.2074E-01	-2.0107E-01	-1.7286E-01	-1.3193E-01	-8.9681E-02	-5.5300E-02	-2.2777E-02	9.3131E-11	
W	-1.4020E-15	-1.6520E-01	-3.2272E-01	-4.7281E-01	-6.1009E-01	-7.5204E-01	-8.9916E-01	-1.0373E-01	-1.1701E+00	
UC	2.0636E+00	2.0625E+00	2.0569E+00	2.0491E+00	2.0350E+00	2.0236E+00	2.0146E+00	2.0039E+00	1.9929E+00	
VC	8.0555E-02	8.3033E-02	9.3624E-02	1.0491E-01	1.2412E-01	1.4182E-01	1.5783E-01	1.7768E-01	1.9995E-01	
WC	-1.2639E-15	1.3968E-02	3.3744E-02	5.7709E-02	8.9140E-02	1.1106E-01	1.2151E-01	1.3297E-01	1.4044E-01	
VCC	8.0555E-02	7.6602E-02	8.5804E-02	9.981E-02	1.2650E-01	1.4373E-01	1.5005E-01	1.5823E-01	1.6334E-01	
VCC	-1.4020E-15	-3.0029E-02	-5.0417E-02	-6.5875E-02	-8.5725E-02	-1.0857E-01	-1.3099E-01	-1.5561E-01	-1.8172E-01	
VX	-1.4020E-15	1.5006E-02	3.6055E-02	6.1688E-02	9.5478E-02	1.2026E-01	1.3411E-01	1.5006E-01	1.6334E-01	
VY	-8.0555E-02	-8.2851E-02	-9.2743E-02	-1.0262E-01	-1.1931E-01	-1.3411E-01	-1.4728E-01	-1.6350E-01	-1.8172E-01	
VZ	2.0636E+00	2.0625E+00	2.0569E+00	2.0491E+00	2.0350E+00	2.0236E+00	2.0146E+00	2.0039E+00	1.9929E+00	
PSINOR	-3.8928E-14	4.1685E-01	1.0535E+00	1.7244E+00	2.6862E+00	3.4011E+00	3.8085E+00	4.2826E+00	4.6857E+00	
THEINOR	8.7764E+01	8.7700E+01	8.7419E+01	8.7134E+01	8.6648E+01	8.6215E+01	8.5828E+01	8.5348E+01	8.4807E+01	
XBAR	0.	1.6668E-01	2.1485E-01	3.2598E-01	4.4176E-01	5.6408E-01	6.9574E-01	8.3940E-01	1.0000E+00	
XBHLD	0.	2.5310E-02	1.2212E-01	1.9464E-01	3.0080E-01	3.9409E-01	5.5067E-01	7.2385E-01	1.0000E+00	
YBAR	-1.7906E-01	-1.7642E-01	-1.6945E-01	-1.5623E-01	-1.3880E-01	-1.1014E-01	-7.9997E-02	-4.3006E-02	2.5256E-10	
YBHL	-1.7906E-01	-1.7843E-01	-1.7545E-01	-1.7092E-01	-1.5927E-01	-1.4480E-01	-1.306E-01	-1.1749E-01	-1.0472E-01	
ETA	9.8827E-02	5.6838E-02	9.1905E-02	8.2780E-02	6.9049E-02	5.2082E-02	3.5227E-02	1.7169E-02	0.	
G	-2.2902E-01	-2.2920E-01	-2.2561E-01	-2.3665E-01	-2.4599E-01	-2.3758E-01	-2.3570E-01	-2.3164E-01	1.1111	
DEQNS	3.9649E+00	3.9728E+00	4.0046E+00	4.0222E+00	4.0784E+00	4.1363E+00	4.1520E+00	4.1619E+00	1.1111	
AM	3.5055E+00	3.5002E+00	3.4717E+00	3.4331E+00	3.3699E+00	3.3193E+00	3.2818E+00	3.2470E+00	3.1998E+00	
CROSSM	3.8522E-01	4.6750E-01	6.4100E-01	8.4201E-01	1.0307E+00	1.2374E+00	1.4604E+00	1.6678E+00	1.8647E+00	
SBAR	9.5057E-03	1.1555E-02	1.8748E-02	2.6807E-02	3.1776E-02	3.3895E-02	3.7531E-02	3.9895E-02	4.1920E-02	
PORDAM	4.5049E-02	4.5164E-02	4.5488E-02	4.5854E-02	4.6084E-02	4.6182E-02	4.6305E-02	4.6404E-02	4.6554E-02	
PT/PTINF	9.7615E-01	9.7133E-01	9.5421E-01	9.3514E-01	9.2363E-01	9.1875E-01	9.1044E-01	9.0508E-01	9.0050E-01	
PT	6.6152E+00	6.5847E+00	6.4660E+00	6.3390E+00	6.2607E+00	6.2276E+00	6.1713E+00	6.1349E+00	6.1039E+00	
BERNCUL	-1.4673E-09	-2.2603E-05	-3.8105E-05	-6.5062E-05	-2.6518E-04	-7.9792E-05	-9.8690E-05	-1.2716E-05	-4.2633E-14	
DPDZ	-2.8905E-03	-2.2989E-03	-2.9002E-04	-3.4311E-03	-7.9212E-03	-7.3315E-03	-6.6726E-03	-4.6826E-03	1.1111	
DUDZ	-4.4855E-02	-4.1754E-02	-3.3874E-02	-2.5394E-02	-1.6710E-02	-8.9617E-03	-3.5843E-03	-1.0328E-03	1.1111	
DVDZ	-4.4238E-01	-4.3647E-01	-4.0807E-01	-3.4440E-01	-2.5547E-01	-1.7576E-01	-1.0762E-01	-4.6455E-02	1.1111	
DMGZ	-1.7205E-15	-8.5117E-04	-8.2508E-03	-4.1784E-03	-2.0462E-02	-1.5604E-02	-1.0979E-02	-7.0054E-03	1.1111	
DSBZ	-1.2057E-01	-7.8062E-03	-2.4458E-02	-2.5644E-02	-1.2643E-02	-1.0346E-02	-9.6887E-03	-3.8594E-03	1.1111	
EP	-2.6433E-16	1.1755E-02	2.7048E-02	6.1337E-02	8.8413E-02	6.7387E-02	6.0449E-02	7.2699E-02	1.1111	
UP	7.4457E-14	-1.6529E-01	-3.2111E-01	-4.390E-01	-5.9693E-01	-7.4209E-01	-8.9559E-01	-1.0355E+00	1.1111	
VP	-4.1737E-15	1.5145E-01	2.7425E-01	4.0193E-01	4.9479E-01	4.4080E-01	3.8403E-01	3.1594E-01	1.1111	
WP	-1.9022E+00	-1.8508E+00	-1.7623E+00	-1.6303E+00	-1.5781E+00	-1.6645E+00	-1.6398E+00	-1.5478E+00	1.1111	
SBARP	9.9924E-17	5.9920E-02	9.4673E-02	7.8010E-02	3.6102E-02	3.1377E-02	3.6050E-02	2.5072E-02	1.1111	
XBSONIC=	4.22915314E-01	YBSONIC=	-1.39964947E-01							

	ZETA= 4.00C00000E-01									
	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
P/RCVSQ	8.6364E-02	8.6511E-02	8.8313E-02	9.1140E-02	9.8064E-02	1.0517E-01	1.1014E-01	1.1643E-01	1.2351E-01	
P/ROASTSQ	3.9481E-01	3.9548E-01	4.0372E-01	4.1664E-01	4.4829E-01	4.8076E-01	5.0348E-01	5.3226E-01	5.6461E-01	
P/PTINF	1.2741E-02	1.2763E-02	1.3029E-02	1.3444E-02	1.4467E-02	1.5515E-02	1.6248E-02	1.7177E-02	1.8221E-02	
P/PTINF	1.9346E+00	1.9375E+00	1.9782E+00	2.0415E+00	2.1966E+00	2.3557E+00	2.4671E+00	2.6081E+00	2.7666E+00	
RHO	1.5913E+00	1.5857E+00	1.6029E+00	1.6303E+00	1.7135E+00	1.7986E+00	1.8543E+00	1.9270E+00	2.0076E+00	
U	2.0576E+00	2.0455E+00	2.0268E+00	1.9921E+00	1.9445E+00	1.8859E+00	1.8132E+00	1.7288E+00	1.6316E+00	
V	-1.8275E-01	-1.7705E-01	-1.6023E-01	-1.3835E-01	-1.0621E-01	-7.1998E-02	-4.4467E-02	-1.8289E-02	9.3131E-11	
W	-1.5449E-15	-1.6487E-01	-3.2146E-01	-4.7305E-01	-6.1204E-01	-7.5347E-01	-9.0018E-01	-1.0380E-01	-1.1701E+00	
UC	2.0631E+00	2.0618E+00	2.0558E+00	2.0486E+00	2.0357E+00	2.0244E+00	2.0152E+00	2.0044E+00	1.9929E+00	
VC	8.4095E-02	8.6558E-02	9.7133E-02	1.0666E-01	1.2302E-01	1.3991E-01	1.5594E-01	1.7627E-01	1.9995E-01	
WC	-1.4607E-15	1.4251E-02	3.4656E-02	5.7353E-02	8.7276E-02	1.0977E-01	1.2063E-01	1.3244E-01	1.4044E-01	
VCC	8.4095E-02	8.0028E-02	8.5216E-02	9.6845E-02	1.2119E-01	1.3477E-01	1.4704E-01	1.5658E-01	1.6334E-01	
VCC	-1.5449E-15	-3.6915E-02	-5.8206E-02	-7.2622E-02	-9.9798E-02	-1.1033E-01	-1.3132E-01	-1.5523E-01	-1.8172E-01	
VX	-1.5449E-15	1.5339E-02	3.7295E-02	6.1396E-02	9.3560E-02	1.1895E-01	1.3308E-01	1.4939E-01	1.6334E-01	
VY	-8.4095E-02	-8.6812E-02	-9.6223E-02	-1.0432E-01	-1.1831E-01	-1.3228E-01	-1.4546E-01	-1.6216E-01	-1.8172E-01	
VZ	2.0631E+00	2.0618E+00	2.0558E+00	2.0486E+00	2.0357E+00	2.0244E+00	2.0152E+00	2.0044E+00	1.9929E+00	
PSINOR	-4.2905E-14	4.2626E-01	1.0393E+00	1.7166E+00	2.6315E+00	3.3601E+00	3.7781E+00	4.2623E+00	4.6857E+00	
THEINOR	8.7666E+01	8.7585E+01	8.7321E+01	8.7086E+01	8.6677E+01	8.6268E+01	8.5880E+01	8.5388E+01	8.4807E+01	
XBAR	0.	1.0628E-01	2.1407E-01	3.2488E-01	4.4045E-01	5.6273E-01	6.9451E-01	8.3880E-01	1.0000E+00	
XBHLD	0.	1.6914E-02	1.0613E-01	1.6346E-01	2.6140E-01	3.3416E-01	4.8030E-01	6.7373E-01	1.0000E+00	
YBAR	-1.5504E-01	-1.5280E-01	-1.4701E-01	-1.3561E-01	-1.1907E-01	-9.6333E-02	-7.0272E-02	-3.8027E-02	2.5256E-10	
YBHL	-1.5504E-01	-1.5468E-01	-1.5281E-01	-1.4973E-01	-1.4214E-01	-1.3428E-01	-1.1166E-01	-7.4382E-02	2.5256E-10	
ETA	7.9061E-02	7.7471E-02	7.3524E-02	6.5824E-02	5.5239E-02	4.1665E-02	2.8181E-02	1.3735E-02	0.	
G	-1.8424E-01	-1.832E-01	-1.8279E-01	-1.8925E-01	-1.9326E-01	-1.9044E-01	-1.8890E-01	-1.8547E-01	1.1111	
DEGAS	4.1993E+00	4.2082E+00	4.2340E+00	4.2399E+00	4.2688E+00	4.3053E+00	4.3123E+00	4.3147E+00	1.1111	
AM	3.5034E+00	3.4968E+00	3.4655E+00	3.4308E+00	3.3728E+00	3.3219E+00	3.2814E+00	3.2489E+00	3.1998E+00	
CROSSM	3.1008E-01	4.0994E-01	6.0488E-01	8.2398E-01	1.0264E+00	1.2373E+00	1.4618E+00	1.6694E+00	1.8647E+00	
SBAR	9.5057E-03	1.2212E-02	2.1533E-02	2.9446E-02	3.2988E-02	3.5056E-02	3.8543E-02	4.0274E-02	4.1920E-02	
PORDAM	4.5069E-02	4.5202E-02	4.5620E-02	4.5977E-02	4.6140E-02	4.6236E-02	4.6397E-02	4.6478E-02	4.6554E-02	
PT/PTINF	9.7652E-01	9.6894E-01	9.4731E-01	9.2903E-01	9.2084E-01	9.1609E-01	9.0814E-01	9.0422E-01	9.0050E-01	
PT	6.6192E+00	6.5678E+00	6.4212E+00	6.2973E+00	6.2418E+00	6.2056E+00	6.1557E+00	6.1291E+00	6.1039E+00	
BERNCUL	-1.4761E-09	-3.9642E-05	-3.0308E-05	-5.2048E-05	-3.0340E-04	-1.2892E-04	-1.1542E-04	-2.7983E-05	-4.2633E-14	
DPDZ	-2.2387E-03	-1.6647E-03	1.6355E-03	2.8177E-03	6.7407E-03	6.6865E-03	6.2484E-03	4.5255E-03	1.1111	
DUDZ	-3.6121E-02	-3.2232E-02	-2.4104E-02	-1.8856E-02	-1.3218E-02	-8.6676E-03	-2.7110E-03	-8.7722E-04	1.1111	
DVDZ	-4.4170E-01	-4.3745E-01	-4.0600E-01	-3.4554E-01	-2.5881E-01	-1.7789E-01	-1.0902E-01	-4.5100E-02	1.1111	
DMGZ	-2.2220E-15	-6.1959E-03	-1.7030E-02	1.2138E-03	1.8647E-02	1.2888E-02	9.4976E-03	6.6866E-03	1.1111	
DSBZ	-5.1934E-01	-1.3305E-02	-3.4204E-02	-2.6731E-02	-1.1658E-02	-1.3190E-02	-1.0489E-02	-3.7074E-03	1.1111	
PP	-6.4082E-16	1.0424E-02	2.4117E-02	5.6515E-02	8.6071E-02	6.7882E-02	6.1582E-02	7.6388E-02	1.1111	
UP	8.7971E-16	-1.7255E-01	-3.3308E-01	-6.7190E-01	-6.0526E-01	-7.4907E-01	-8.9949E-01	-1.0373E+00	1.1111	
VP	-2.4170E-15	1.3467E-01	2.2196E-01	3.1152E-01	3.9518E-01	3.5599E-01	3.0800E-01	2.5409E-01	1.1111	
WP	-1.8996E+00	-1.8413E+00	-1.7640E+00	-1.6531E+00	-1.5815E+00	-1.6570E+00	-1.6359E+00	-1.5620E+00	1.1111	
SBARP	3.1334E-16	1.0517E-02	1.0561E-02	4.6986E-02	2.6655E-02	3.2004E-02	3.1243E-02	1.9292E-02	1.1111	
XBSONIC=	4.2537666E-01	YBSONIC=	-1.21229972E-01							

APPENDIX C

	ZETA= 3.0CCCCCCCC-01									
	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
P/RCVSO	8.6502E-02	6.4649E-02	8.0246E-02	9.0081E-02	9.7441E-02	1.0453E-01	1.0953E-01	1.1559E-01	1.2351E-01	
P/ROASTSO	3.9571E-01	3.5611E-01	4.0314E-01	4.1946E-01	4.4545E-01	4.7745E-01	5.0072E-01	5.2022E-01	5.4641E-01	
P/PTINF	1.2770E-02	1.2703E-02	1.3026E-02	1.3408E-02	1.4375E-02	1.5421E-02	1.6159E-02	1.7111E-02	1.8221E-02	
P/PTINF	1.9340E+00	1.4405E+00	1.5778E+00	2.0357E+00	2.1827E+00	2.3414E+00	2.4535E+00	2.5981E+00	2.7666E+00	
RHC	1.5939E+00	1.5894E+00	1.5580E+00	1.6240E+00	1.7043E+00	1.7888E+00	1.8456E+00	1.9212E+00	2.0076E+00	
U	2.0558E+00	2.0521E+00	2.0287E+00	1.9437E+00	1.9456E+00	1.8865E+00	1.8134E+00	1.7288E+00	1.6316E+00	
V	-1.3852E-01	-1.3319E-01	-1.1538E-01	-1.0383E-01	-8.0180E-02	-5.4109E-02	-3.3501E-02	-1.3758E-02	9.3131E-11	
W	-1.4884E-15	-1.6381E-01	-3.1928E-01	-4.7321E-01	-6.1379E-01	-7.5457E-01	-9.0107E-01	-1.0386E+00	-1.1701E+00	
UC	2.0626E+00	2.0609E+00	2.0544E+00	2.0480E+00	2.0362E+00	2.0249E+00	2.0159E+00	2.0050E+00	1.9929E+00	
VC	6.7616E-02	6.1061E-02	1.0058E-01	1.0829E-01	1.2221E-01	1.3818E-01	1.5417E-01	1.7491E-01	1.9995E-01	
WC	-1.3312E-15	1.5297E-02	3.6647E-02	5.7072E-02	8.5804E-02	1.0877E-01	1.1986E-01	1.3192E-01	1.4044E-01	
VCC	4.7616E-02	6.0693E-02	8.4218E-02	5.3155E-02	1.1595E-01	1.3549E-01	1.4417E-01	1.5496E-01	1.6334E-01	
WCC	-1.4684E-15	-4.4881E-02	-6.6197E-02	-7.9417E-02	-9.3915E-02	-1.1211E-01	-1.3171E-01	-1.5487E-01	-1.8172E-01	
VX	-1.4884E-15	1.6381E-02	3.9372E-02	6.1180E-02	9.1848E-02	1.1774E-01	1.3216E-01	1.4874E-01	1.6334E-01	
VY	-8.7416E-02	-9.0688E-02	-9.9622E-02	-1.0603E-01	-1.1759E-01	-1.3063E-01	-1.4376E-01	-1.6085E-01	-1.8172E-01	
VZ	2.0626E+00	2.0609E+00	2.0544E+00	2.0480E+00	2.0362E+00	2.0249E+00	2.0159E+00	2.0050E+00	1.9929E+00	
PSINCF	-4.1268E-14	4.5581E-01	1.0580E+00	1.7111E+00	2.5827E+00	3.3276E+00	3.7512E+00	4.2427E+00	4.8857E+00	
THEFNDR	8.7506E+01	8.7475E+01	8.7224E+01	8.7038E+01	8.6698E+01	8.6319E+01	8.5930E+01	8.5426E+01	8.4807E+01	
XEAR	U.	1.0588E-01	2.1529E-01	3.2375E-01	4.3915E-01	5.6139E-01	6.9330E-01	8.3800E-01	1.0000E+00	
XBLU	U.	1.0632E-02	6.0713E-02	1.3418E-01	2.0631E-01	2.8364E-01	4.1191E-01	6.2245E-01	1.0000E+00	
YEAR	-1.3114E-01	-1.2931E-01	-1.2447E-01	-1.1508E-01	-1.0140E-01	-8.2560E-02	-6.0562E-02	-3.3052E-02	2.5256E-10	
YBLU	-1.3114E-01	-1.3766E-01	-1.2999E-01	-1.2803E-01	-1.2479E-01	-1.1849E-01	-1.0737E-01	-7.2377E-02	2.5256E-10	
ETA	5.9256E-02	5.8103E-02	5.5143E-02	4.9368E-02	4.1429E-02	3.1249E-02	2.1136E-02	1.0301E-02	0.	
G	-1.3945E-01	-1.3780E-01	-1.3600E-01	-1.4142E-01	-1.4298E-01	-1.4552E-01	-1.4298E-01	-1.3921E-01	11111	
DEGNS	4.3770E+00	4.3800E+00	4.4050E+00	4.4035E+00	4.4151E+00	4.4347E+00	4.4353E+00	4.4325E+00	11111	
AP	3.5018E+00	3.4926E+00	3.4554E+00	3.4283E+00	3.3752E+00	3.3236E+00	3.2881E+00	3.2447E+00	3.1998E+00	
CROSSP	4.5057E-03	1.4443E-02	2.5714E-02	3.2022E-02	3.4170E-02	3.6608E-02	3.9601E-02	4.0631E-02	4.1920E-02	
SEAR	4.5089E-02	4.5292E-02	4.5806E-02	4.6095E-02	4.6195E-02	4.6307E-02	4.6444E-02	4.6544E-02	4.6544E-02	
POROGAM	9.7652E-01	9.6494E-01	9.3774E-01	9.2307E-01	9.1812E-01	9.1254E-01	9.0574E-01	9.0341E-01	9.0050E-01	
PT/PTINF	6.6152E+00	6.5380E+00	6.3563E+00	6.2565E+00	6.1855E+00	6.1354E+00	6.0934E+00	6.1236E+00	6.1039E+00	
BERNCUL	-1.2175E-04	-6.5531E-05	1.0452E-05	-4.3831E-05	3.0825E-04	-1.8724E-04	-1.1751E-04	4.9084E-05	4.2633E-14	
DPDZ	-1.7514E-03	-1.1091E-03	3.2616E-04	2.3727E-04	5.7454E-03	6.0856E-03	5.8625E-03	4.3768E-03	11111	
DUOZ	-2.3737E-02	-2.1264E-02	-1.2652E-02	-1.3146E-02	-9.7713E-03	-4.3643E-03	-1.8695E-03	-7.4472E-04	11111	
UVDZ	-4.4340E-01	-4.3588E-01	-4.3511E-01	-4.3511E-01	-2.6188E-01	-1.7987E-01	-1.1028E-01	-4.5517E-02	11111	
DMOZ	-3.0016E-15	-1.6125E-02	-2.6693E-02	-2.5033E-02	1.5785E-02	8.7649E-03	8.1305E-03	6.4416E-03	11111	
CSB0Z	-1.3340E-30	-2.4554E-02	-4.7647E-02	-2.3780E-02	-1.2653E-02	-1.8235E-02	-1.0409E-02	-3.3943E-03	11111	
PP	-6.5245E-10	9.1776E-03	2.1478E-02	5.2040E-02	8.3738E-02	6.8159E-02	6.2647E-02	7.9846E-02	11111	
UP	4.6818E-14	-1.6150E-01	-3.3657E-01	-4.7530E-01	-6.1148E-01	-7.5466E-01	-9.0209E-01	-1.0386E+00	11111	
VP	-1.0057E-15	1.1775E-01	1.6833E-01	2.2333E-01	2.9677E-01	2.6984E-01	2.3103E-01	1.9139E-01	11111	
WP	-1.6876E+00	-1.8255E+00	-1.7724E+00	-1.6805E+00	-1.5893E+00	-1.6300E+00	-1.6342E+00	-1.5369E+00	11111	
SEARP	6.3347E-16	1.0673E-01	1.1041E-01	4.3305E-02	2.1722E-02	3.3172E-02	2.3265E-02	1.3250E-02	11111	
XBSCNIC*	4.2658154E-01 YBSCNIC* -1.02890521E-01									

	ZETA= 2.0CCCCCCCC-01									
	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
P/ROVSW	8.6718E-02	6.6733E-02	8.0248E-02	9.0662E-02	9.6410E-02	1.0349E-01	1.0896E-01	1.1556E-01	1.2351E-01	
P/ROASTSW	3.9642E-01	3.5649E-01	4.0342E-01	4.1445E-01	4.4032E-01	4.7151E-01	4.9812E-01	5.2826E-01	5.6461E-01	
P/PTINF	1.2793E-02	1.2766E-02	1.3019E-02	1.3375E-02	1.4257E-02	1.5339E-02	1.6675E-02	1.7048E-02	1.8221E-02	
P/PTINF	1.9425E+00	1.4428E+00	1.5768E+00	2.0308E+00	2.1708E+00	2.3244E+00	2.4408E+00	2.5885E+00	2.7666E+00	
RHC	1.5460E+00	1.5855E+00	1.5911E+00	1.6190E+00	1.6956E+00	1.7750E+00	1.8375E+00	1.9157E+00	2.0076E+00	
U	2.0621E+00	2.0536E+00	2.0294E+00	1.9484E+00	1.9463E+00	1.8868E+00	1.8136E+00	1.7289E+00	1.6316E+00	
V	-9.3430E-02	-6.9014E-02	-7.8450E-02	-6.9355E-02	-5.3367E-02	-3.6034E-02	-2.2416E-02	-9.1868E-03	9.3131E-11	
W	-2.6291E-15	-1.6129E-01	-3.1624E-01	-4.7387E-01	-6.1496E-01	-7.5521E-01	-9.0188E-01	-1.0393E+00	-1.1701E+00	
UC	2.0623E+00	2.0595E+00	2.0524E+00	2.0478E+00	2.0365E+00	2.0252E+00	2.0163E+00	2.0055E+00	1.9929E+00	
VC	9.1451E-02	6.5380E-02	1.0382E-01	1.0990E-01	1.2166E-01	1.3661E-01	1.5251E-01	1.7358E-01	1.9995E-01	
WC	-2.4723E-15	1.7689E-02	3.5612E-02	5.6341E-02	8.4439E-02	1.0813E-01	1.1915E-01	1.3143E-01	1.4044E-01	
VCC	9.1451E-02	6.0743E-02	8.2544E-02	8.8356E-02	1.1105E-01	1.3186E-01	1.4338E-01	1.5338E-01	1.6334E-01	
WCC	-2.6291E-15	-5.3767E-02	-7.4388E-02	-8.6283E-02	-9.7779E-02	-1.1487E-01	-1.3215E-01	-1.5453E-01	-1.8172E-01	
VX	-2.6291E-15	1.8882E-02	4.2218E-02	6.0511E-02	9.0656E-02	1.1699E-01	1.3132E-01	1.4811E-01	1.6334E-01	
VY	-9.1451E-02	-5.5191E-02	-1.0278E-01	-1.0766E-01	-1.1710E-01	-1.2910E-01	-1.4216E-01	-1.5958E-01	-1.8172E-01	
VZ	2.0623E+00	2.0595E+00	2.0524E+00	2.0478E+00	2.0365E+00	2.0252E+00	2.0163E+00	2.0055E+00	1.9929E+00	
PSINCF	-7.3046E-14	5.2527E-01	1.1784E+00	1.6926E+00	2.5489E+00	3.3063E+00	3.7626E+00	4.2239E+00	4.8857E+00	
THEFNDR	8.7461E+01	8.7395E+01	8.7134E+01	8.6992E+01	8.6712E+01	8.6358E+01	8.5975E+01	8.5463E+01	8.4807E+01	
XEAR	U.	1.0548E-01	2.1529E-01	3.2270E-01	4.3785E-01	5.6005E-01	6.9208E-01	8.3721E-01	1.0000E+00	
XBLU	U.	6.1415E-03	3.8536E-02	9.7950E-02	1.6185E-01	2.0030E-01	3.1191E-01	5.2840E-01	1.0000E+00	
YEAR	-1.0735E-01	-1.0591E-01	-1.0203E-01	-5.4612E-02	-8.3780E-02	-6.8816E-02	-5.0867E-02	-2.8081E-02	2.5256E-10	
YBLU	-1.0735E-01	-1.0727E-01	-1.0682E-01	-1.0601E-01	-1.0387E-01	-1.0247E-01	-9.5338E-02	-7.2692E-02	2.5256E-10	
ETA	3.9531E-02	3.8735E-02	3.6162E-02	3.2912E-02	2.7620E-02	2.0433E-02	1.4091E-02	6.8675E-03	0.	
G	-9.4395E-02	-4.1951E-02	-8.9516E-02	-9.4605E-02	-9.7410E-02	-9.5270E-02	-9.2867E-02	-8.2867E-02	11111	
DEGNS	4.4568E+00	4.5043E+00	4.5173E+00	4.5126E+00	4.5194E+00	4.5229E+00	4.5199E+00	4.5149E+00	11111	
AP	3.5005E+00	3.4357E+00	3.4498E+00	3.4288E+00	3.3761E+00	3.3239E+00	3.2880E+00	3.2446E+00	3.1998E+00	
CROSSM	1.5228E-01	3.1144E-01	5.4698E-01	7.9959E-01	1.0207E+00	1.2344E+00	1.4644E+00	1.6727E+00	1.8647E+00	
SEAR	9.5057E-03	1.8020E-02	3.1239E-02	3.3925E-02	3.5862E-02	3.8738E-02	4.0527E-02	4.0952E-02	4.1920E-02	
POROGAM	4.5089E-02	4.5495E-02	4.6059E-02	4.6183E-02	4.6273E-02	4.6406E-02	4.6489E-02	4.6509E-02	4.6554E-02	
PT/PTINF	9.7652E-01	9.5555E-01	9.2487E-01	9.1866E-01	9.1425E-01	9.0770E-01	9.0365E-01	9.0269E-01	9.0050E-01	
PT	6.6192E+00	6.4798E+00	6.2691E+00	6.2272E+00	6.1971E+00	6.1527E+00	6.1252E+00	6.1187E+00	6.1039E+00	
BERNCUL	4.9617E-10	-5.0813E-05	1.1375E-04	-1.1446E-04	2.8680E-04	-2.3640E-04	-9.3962E-05	7.5642E-05	4.2633E-14	
DPDZ	-1.3733E-03	-5.7228E-04	6.2168E-04	2.0387E-03	4.9035E-03	5.5224E-03	5.5108E-03	4.2333E-03	11111	
DUOZ	-1.8560E-02	-6.0090E-03	-1.4439E-04	-1.0640E-02	-4.2273E-03	-1.4425E-03	-1.3857E-03	-6.3517E-04	11111	
UVDZ	-4.4947E-01	-4.4314E-01	-4.4457E-01	-3.4378E-01	-2.6462E-01	-1.8150E-01	-1.1140E-01	-4.5909E-02	11111	
DMOZ	-2.5336E-15	-3.7144E-02	-3.2457E-02	-1.1966E-02	5.7451E-03	4.2444E-03	8.1929E-03	6.2263E-03	11111	
OSB0Z	-5.2503E-30	-5.1078E-02	-6.2378E-02	-1.2744E-02	-2.4253E-02	-2.3419E-02	-7.4416E-03	-3.0580E-03	11111	
PP	-2.3410E-16	7.9170E-03	2.0219E-02	4.9590E-02	6.1489E-02	6.8113E-02	6.3094E-02	8.3093E-02	11111	
UP	5.7110E-15	1.5917E-03	3.3721E-01	4.3361E-01	-0.1753E-01	-7.5802E-01	-9.0306E-01	-1.0395E+00	11111	
VP	-2.0964E-16	9.7324E-02	1.1158E-01	1.3466E-01	2.0026E-01	1.8222E-01	1.5322E-01	1.2807E-01	11111	
WP	-1.8550E+00	-1.6042E+00	-1.1950E+00	-1.7100E+00	-1.5854E+00	-1.4672E+00	-1.3532E+00	-1.2322E+00	11111	
SEARP	9.5351E-16	1.5914E-01	9.6616E-01	1.5458E-02	2.7619E-02	2.8947E-02	1.1092E-02	7.9580E-03	11111	
XBSCNIC=	4.270554eCE=U1	YBSCNIC=	E.4755886eF-02							

APPENDIX C

ZETA= 1.0000000E-01

	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
P/RCVSQ	8.6837E-02	8.6764E-02	8.6114E-02	9.0470E-02	9.6457E-02	1.0342E-01	1.0843E-01	1.1514E-01	1.2351E-01	
P/RCASISQ	3.9697E-01	3.5664E-01	4.0308E-01	4.1358E-01	4.4095E-01	4.7279E-01	4.9567E-01	5.2635E-01	5.6461E-01	
P/PTINF	1.2811E-02	1.2800E-02	1.3008E-02	1.3347E-02	1.4230E-02	1.5258E-02	1.5996E-02	1.5986E-02	1.8221E-02	
P/PIAF	1.9451E+00	1.5433E+00	1.5751E+00	2.0265E+00	2.1606E+00	2.3167E+00	2.4288E+00	2.5791E+00	2.7666E+00	
RHO	1.5975E+00	1.5774E+00	1.5833E+00	1.5155E+00	1.9466E+00	1.7704E+00	1.8304E+00	1.9103E+00	2.0076E+00	
U	2.0635E+00	2.0528E+00	2.0290E+00	1.9959E+00	1.9460E+00	1.8870E+00	1.8137E+00	1.7299E+00	1.6316E+00	
V	-4.8288E-02	-4.4487E-02	-3.8583E-02	-3.4976E-02	-2.7249E-02	-1.7824E-02	-1.1223E-02	-4.5773E-03	9.3131E-11	
W	-2.5765E-15	-1.5535E-01	-3.1388E-01	-4.7513E-01	-6.1423E-01	-7.5598E-01	-9.0263F-01	-1.0399E+00	-1.1701E+00	
UC	2.0619E+00	2.0566E+00	2.0503E+00	2.0482E+00	2.0355E+00	2.0255E+00	2.0168E+00	2.0059E+00	1.9929E+00	
VC	9.6303E-02	9.9535E-02	1.0649E-01	1.1147E-01	1.2132E-01	1.3519E-01	1.5095E-01	1.7229E-01	1.9995E-01	
WCC	-2.4113E-15	2.3410E-02	4.1672E-02	5.9166E-02	8.4831E-02	1.0741E-01	1.1850E-01	1.3095E-01	1.4044E-01	
VCC	9.6303E-02	9.9535E-02	7.8615E-02	8.2445E-02	1.0751E-01	1.2816E-01	1.3868E-01	1.5183E-01	1.6334E-01	
WCC	-2.5765E-15	2.4659E-02	-8.3038E-02	-9.3122E-02	-1.0177E-01	-1.1571E-01	-1.3265E-01	-1.5442E-01	-1.8172E-01	
VX	-2.5765E-15	2.4659E-02	4.4345E-02	5.9396E-02	9.1030E-02	1.1618E-01	1.3055E-01	1.4751E-01	1.6334E-01	
VY	-9.6303E-02	-5.9635E-02	-1.0540E-01	-1.0927E-01	-1.1674E-01	-1.2773E-01	-1.4067E-01	-1.5485E-01	-1.7172E-01	
VZ	2.0619E+00	2.0566E+00	2.0503E+00	2.0482E+00	2.0355E+00	2.0255E+00	2.0168E+00	2.0059E+00	1.9929E+00	
PSINCR	-7.1550E-14	6.8656E-01	1.2390E+00	1.6611E+00	2.5607E+00	3.2828E+00	3.7035E+00	4.2058E+00	4.6857E+00	
THETAQR	8.7326E+01	6.7227E+01	8.7058E+01	8.6947E+01	8.6721E+01	8.6398E+01	8.6019E+01	8.5499E+01	8.4807E+01	
XBAR	0.	1.0509E-01	2.1114E-01	3.2162E-01	4.3655E-01	5.5871E-01	6.9086E-01	8.3641E-01	1.0000E+00	
XBHLD	0.	3.0665E-03	1.9369E-02	4.9232E-02	9.6366E-02	1.3785E-01	1.7634E-01	2.3881E-01	1.0000E+00	
YBAR	-8.3642E-02	-8.2546E-02	-7.9653E-02	-7.4205E-02	-6.6204E-02	-5.5099E-02	-4.1186E-02	-2.3114E-02	2.5256E-10	
YBHL	1.9765E-02	1.5361E-02	1.8381E-02	1.6456E-02	1.3810E-02	1.0416E-02	7.3453E-03	3.4338E-03	0.	
G	-4.8415E-02	-4.5810E-02	-4.3865E-02	-4.7557E-02	-4.8939E-02	-4.7439E-02	-4.7382E-02	-4.6437E-02	1.1111	
DECS	4.5646E+00	4.5683E+00	4.5715E+00	4.5683E+00	4.5680E+00	4.5686E+00	4.5655E+00	4.5613E+00	1.1111	
AM	3.4421E+00	3.4706E+00	3.4397E+00	3.4725E+00	3.3713E+00	3.3247E+00	3.2903E+00	3.2485E+00	3.1998E+00	
CROSSP	8.1869E-02	7.2326E-01	5.2572E-01	7.9578E-01	1.0157E+00	1.2367E+00	1.4661E+00	1.6743E+00	1.8647E+00	
SBAR	9.5057E-03	3.8282E-02	3.7280E-02	3.4835E-02	4.0288E-02	4.0453E-02	4.1039E-02	4.1292E-02	4.1920E-02	
PODOGAM	4.5065E-02	4.5383E-02	4.5399E-02	4.6226E-02	4.6478E-02	4.6486E-02	4.6513E-02	4.6525E-02	4.6554E-02	
PT/PTINF	9.7652E-01	9.3617E-01	1.1101E-01	9.1659E-01	9.0419E-01	9.0381E-01	9.0249E-01	9.0192E-01	9.0059E-01	
PT	6.6152E+00	6.3457E+00	6.1752E+00	6.1303E+00	6.1289E+00	6.1264E+00	6.1174E+00	6.1135E+00	6.1039E+00	
BERNCLL	1.2800E-08	-4.6614E-05	1.8458E-04	-4.2679E-04	4.5176E-04	-3.3708E-04	3.4899E-04	1.0122E-04	4.2633E-14	
DDOZ	-5.8450E-04	-5.4008E-05	8.3998E-04	1.8127E-03	4.1683E-03	4.9943E-03	5.1936E-03	5.1009E-03	1.1111	
DUOZ	-9.5443E-03	2.6565E-02	3.1257E-02	-1.6389E-03	1.2925E-02	-6.8445E-03	6.8026E-04	4.9960E-04	1.1111	
DVOZ	-4.6021E-01	-4.5886E-01	-3.9638E-01	-3.4475E-01	-2.6137E-01	-1.8252E-01	-1.1249E-01	-6.2765E-02	1.1111	
DWZ	-5.8466E-15	-5.0507E-02	-2.7822E-03	5.2549E-03	-2.0651E-02	1.5588E-02	4.0899E-03	6.1088E-03	1.1111	
DSBCL	-7.8650E-03	-1.3367E-01	-4.6171E-02	-1.5646E-02	-6.7924E-02	6.9841E-02	-6.4870E-03	-3.8887E-03	1.1111	
PP	-2.6086E-10	6.6583E-03	1.9067E-02	4.7233E-02	7.9386E-02	6.7702E-02	6.3490E-02	6.1505E-02	1.1111	
UP	-8.0279E-15	-2.0498E-01	-3.2182E-01	-4.7624E-01	-6.2429E-01	-7.5374E-01	-9.4464E-01	-1.0402E+00	1.1111	
V	1.8181E-10	6.4889E-02	5.2419E-02	6.0953E-02	1.0460E-01	9.3125E-02	7.4960E-02	6.4121E-02	1.1111	
W	-1.7651E+00	-1.7964E+00	-1.8511E+00	-1.7160E+00	-1.5788E+00	-1.4659E+00	-1.3333E+00	-1.2579E+00	1.1111	
SEARP	7.4018E-16	2.0352E-01	3.5104E-01	5.5164E-01	3.9189E-02	-4.2074E-04	4.8333E-03	5.0313E-03	1.1111	

XBSCNIC= 4.28370475E-01 YBSCNIC= -6.67142518E-02

ZETA= 0.

	I=1	I=2	I=3	I=4	I=5	I=6	I=7	I=8	I=9	I=10
P/RCVSQ	8.6916E-02	8.6744E-02	8.8062E-02	9.0295E-02	9.6073E-02	1.0295E-01	1.0792E-01	1.1474E-01	1.2351E-01	
P/RCASISQ	3.9733E-01	3.9655E-01	4.0266E-01	4.1278E-01	4.3919E-01	4.7062E-01	4.9336E-01	5.2451E-01	5.6461E-01	
P/PTINF	1.2823E-02	1.2747E-02	1.2545E-02	1.3321E-02	1.4173E-02	1.5188E-02	1.5922E-02	1.6927E-02	1.8221E-02	
P/PIAF	1.9469E+00	1.5433E+00	1.5730E+00	2.0226E+00	2.1520E+00	2.3080E+00	2.4175E+00	2.5701E+00	2.7666E+00	
RHO	1.5620E+00	1.5948E+00	1.5769E+00	1.6051E+00	1.6778E+00	1.7627E+00	1.8232E+00	1.9046E+00	2.0076E+00	
U	2.0541E+00	2.0433E+00	2.0283E+00	1.9946E+00	1.9462E+00	1.8868E+00	1.8138E+00	1.7289E+00	1.6316E+00	
V	-3.8551E-04	1.3703E-04	3.9875E-04	-3.5704E-04	-3.8212E-04	4.4522E-04	7.8772E-05	6.7609E-05	9.3131E-11	
W	1.9827E-14	-1.4451E-01	-3.1294E-01	-4.7071E-01	-6.1641E-01	-7.5564E-01	-9.0325E-01	-1.0407E+00	-1.1701E+00	
UC	2.0515E+00	2.0514E+00	2.0492E+00	2.0454E+00	2.0362E+00	2.0252E+00	2.0173E+00	2.0065E+00	1.9929E+00	
VC	1.0290E-01	1.0654E-01	1.0611E-01	1.1055E-01	1.2136E-01	1.3378E-01	1.4951E-01	1.7104E-01	1.9995E-01	
WCC	2.0003E-14	3.3885E-02	4.1423E-02	5.9018E-02	8.2781E-02	1.0761E-01	1.1800E-01	1.3024E-01	1.4044E-01	
VCC	1.0290E-01	6.1934E-02	7.0663E-02	8.0784E-02	1.0142E-01	1.2533E-01	1.3615E-01	1.5009E-01	1.6334E-01	
WCC	-1.9427E-14	1.3223E-02	-5.1479E-02	-5.8123E-02	-1.0627E-01	-1.1795E-01	-1.3395E-01	-1.5395E-01	-1.8172E-01	
VX	1.9827E-14	1.5171E-02	4.4138E-02	6.3305E-02	8.8985E-02	1.1629E-01	1.2992E-01	1.4667E-01	1.6334E-01	
VY	-1.0250E-01	-1.0411E-01	-1.0703E-01	-1.1074E-01	-1.1688E-01	-1.2631E-01	-1.3927E-01	-1.5717E-01	-1.8172E-01	
VZ	2.0515E+00	2.0514E+00	2.0492E+00	2.0454E+00	2.0362E+00	2.0252E+00	2.0173E+00	2.0065E+00	1.9929E+00	
PSINCR	5.3372E-13	5.8222E-01	1.2339E+00	1.7729E+00	2.5023E+00	3.2863E+00	3.6850E+00	4.1808E+00	4.6857E+00	
THETAQR	8.7129E+01	8.7055E+01	8.7011E+01	8.6902E+01	8.6718E+01	8.6437E+01	8.6059E+01	8.5532E+01	8.4807E+01	
XBAR	0.	1.0605E-01	2.1098E-01	3.2053E-01	4.3526E-01	5.5738E-01	6.8965E-01	8.3656E-01	1.0000E+00	
XBHLD	0.	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	
YBAR	-6.0000E-02	-9.3652E-02	-5.7339E-02	-3.3855E-02	-4.0666E-02	-4.1406E-02	-3.1517E-02	-1.8150E-02	2.5256E-10	
YBHL	0.	2.5256E-10	2.5256E-10	2.5256E-10	2.5256E-10	2.5256E-10	2.5256E-10	2.5256E-10	2.5256E-10	
G	-4.8415E-02	-4.5810E-02	-4.3865E-02	-4.7557E-02	-4.8939E-02	-4.7439E-02	-4.7382E-02	-4.6437E-02	1.1111	
DECS	4.5646E+00	4.5683E+00	4.5715E+00	4.5683E+00	4.5680E+00	4.5686E+00	4.5655E+00	4.5613E+00	1.1111	
AM	3.4421E+00	3.4435E+00	3.4328E+00	3.4154E+00	3.3723E+00	3.3245E+00	3.2920E+00	3.2500E+00	3.1998E+00	
CROSSP	3.3223E-14	2.4222E-01	5.2508E-01	7.8448E-01	1.0182E+00	1.2360E+00	1.4675E+00	1.6761E+00	1.8647E+00	
SBAR	4.1920E-02	4.1920E-02	4.1920E-02	4.1920E-02	4.1920E-02	4.1920E-02	4.1920E-02	4.1920E-02	4.1920E-02	
PODOGAM	4.6554E-02	4.6554E-02	4.6554E-02	4.6554E-02	4.6554E-02	4.6554E-02	4.6554E-02	4.6554E-02	4.6554E-02	
PT/PTINF	9.0050E-01	9.0050E-01	9.0050E-01	9.0050E-01	9.0050E-01	9.0050E-01	9.0050E-01	9.0050E-01	9.0050E-01	
PT	6.1039E+00	6.1039E+00	6.1039E+00	6.1039E+00	6.1039E+00	6.1039E+00	6.1039E+00	6.1039E+00	6.1039E+00	
BERNCLL	-2.4770E-08	-3.5559E-05	-2.5580E-08	-2.4020E-08	-2.8449E-08	-3.0347E-08	-3.5163E-08	-4.9487E-09	4.2633E-14	
DDOZ	-4.7985E-01	-4.4788E-01	-3.9212E-01	-3.4727E-01	-2.6701E-01	-1.8408E-01	-1.1252E-01	-6.4974E-02	1.1111	
DUOZ	6.1270E-30	3.4571E-04	1.5837E-03	3.2443E-03	4.8804E-03	5.8119E-03	5.8095E-03	3.9269E-03	1.1111	
PP	6.1037E-16	6.4755E-03	1.8642E-02	6.4281E-02	7.8407E-02	6.7382E-02	6.3608E-02	8.7611E-02	1.1111	
UP	1.9827E-14	-1.4451E-01	-3.1394E-01	-4.7071E-01	-6.1641E-01	-7.5564E-01	-9.0325E-01	-1.0407E+00	1.1111	
W	-1.6055E+00	-1.6055E+00	-1.6883E+00	-1.6937E+00	-1.6012E+00	-1.6600E+00	-1.6259E+00	-1.5295E+00	1.1111	

XBSCNIC= 4.26306262E-01 YBSCNIC= -4.56710252E-02

WINDOW LINE ZETA LIMIT

U	RHO	S	PODOGAM	UC	VC	WC	VX	VY	VZ	PT/PTINF
2.0640E+00	1.5975E+00	5.5057E-03	4.5069E-02	2.0614E+00	1.0378E-01	1.7800E-16	0.	-1.0378E-01	2.0614E+00	9.7652E-01
CPI11 AT ZETA=0										
8.4525257E-02	8.42031584E-02	8.68791277E-02	9.13052188E-02	1.02859557E-01	1.16611573E-01	1.26561463E-01	1.40185412E-01			
1.57125710E-01										
-3.58151380E-04	1.37034559E-04	3.5E745557E-04	-3.57341751E-04	-3.82119113E-04	4.45217430E-04	7.87718496E-05	6.76090849E-05			
9.31310159E-11										

APPENDIX C

Explanatory Notes

- ① Some input and auxiliary parameters.
- ② Initial shock shape and quantities computed from the first pivotal integration.
- ③ Change in the shock shape computed by regular Newton method. (See ref. 1.)
Note that the results of the N variational integrations are not printed.
- ④ Shock shape for second pivotal integration and computed quantities from this integration. Since $V_{MAX} < V_{TEST1}$ at this stage, the modified Newton method (ref. 1) is used to compute corrections to the shock shape; that is, the previously computed Jacobian matrix is used, and consequently, $DETERM$ is equal to the value from the previously computed value. Note that a modified Newton iteration cycle requires only one integration, since the N variational runs are bypassed.
- ⑤ Change in shock shape computed by modified Newton method.
- ⑥ Shock shape for third pivotal integration and computed quantities.
- ⑦ New correction to shock shape computed by modified Newton method.
- ⑧ Shock shape for fourth pivotal integration and computed quantities.
- ⑨ New correction to shock shape computed by modified Newton method.
- ⑩ Shock shape for fourth pivotal integration and computed quantities. The solution now satisfies the convergence criterion $V_{MAX} < V_{TESTHD}$.
- ⑪ Some input, auxiliary, and secondary parameters printed beginning on a new page.
- ⑫ Coordinates of Mach cone behind shock centered at wing apex.
- ⑬ Summary print block.
- ⑭ Arc length, wing coordinates, and shock quantities.
- ⑮ Zeta print block at shock.
- ⑯ Sonic-line coordinates referenced to wing semispan.
- ⑰ Zeta print block at wing surface.
- ⑱ Windward-line zeta limit.

APPENDIX C

- ⑪ Surface-pressure coefficients and normal velocities.
- ⑫ Force coefficients and center-of-pressure location.

REFERENCES

1. Klunker, E. B.; South, Jerry C., Jr.; and Davis, Ruby M.: Calculation of Nonlinear Conical Flows by the Method of Lines. NASA TR R-374, 1971.
2. Klunker, E. B.; South, Jerry C., Jr.; and Davis, Ruby M.: Computer Program for Calculating Supersonic Flow About Circular, Elliptic, and Bielliptic Cones by the Method of Lines. NASA TM X-2437, 1972.



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